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Onsite Control of Sedimentation Utilizing the Modified Block-Cut Method of Surface Mining

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ONSITE CONTROL OF SEDIMENTATION UTILIZING THE MODIFIED BLOCK-CUT METHOD OF SURFACE MINING

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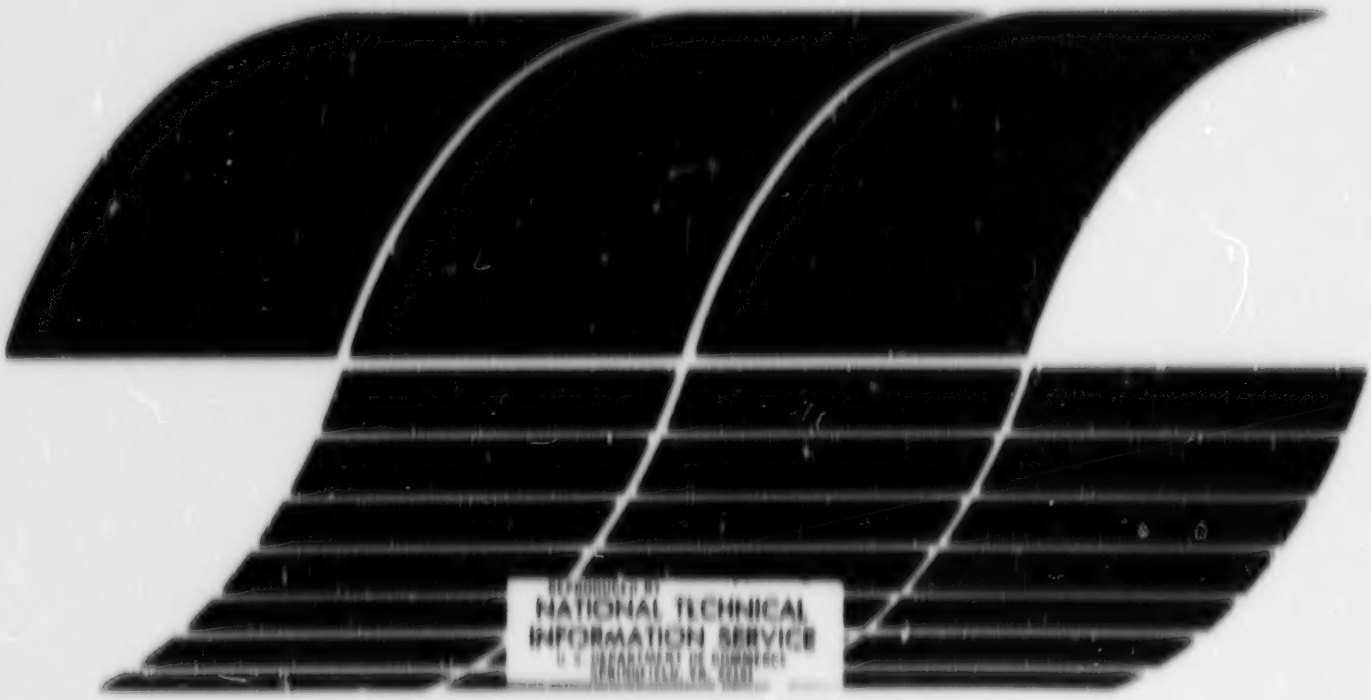

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Calculations indicate the sediment yield from the mining operation will be within the water quality standards of the Commonwealth of Kentucky. All operations proposed in the demonstration project meet present State regulations for surface mining.

Based on certain assumptions, a comparison of costs involved in the modified block-cut method of mining and in a method using the minimum acceptable requirements as set forth in the present regulations has been prepared. The differential in costs of the two methods appears to be negligible. The demonstration will prove that the need for sediment basins with the modified block-cut method of mining will be minimized or perhaps eliminated, depending on future State and Federal regulations.

A water quality monitoring station will be constructed to provide data before, during, and after the mining operation.

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ONSITE CONTROL OF SEDIMENTATION UTILIZING THE MODIFIED BLOCK-CUT METHOD OF SURFACE MINING

by

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and Environmental Protection
Commonwealth of Kentucky

and

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report describes the results of a feasibility study to show that the modified block-cut method of surface mining can provide onsite control of sedimentation. A site was selected and a detailed site survey and subsurface investigation was performed. Preliminary plans for a demonstration project were developed. For further information contact the Resource Extraction and Handling Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

The objective of this study was to determine the feasibility of a demonstration project for onsite control of sedimentation utilizing the modified block-cut method of surface mining. A project site on Lower Lick Fork in Perry and Letcher Counties in Kentucky was selected. A detailed site survey and subsurface investigation was conducted, and preliminary plans were developed.

Calculations indicate the sediment yield from the mining operation will be within the water quality standards of the Commonwealth of Kentucky. All operations proposed in the demonstration project meet present State regulations for surface mining.

Based on certain assumptions, a comparison of costs involved in the modified block-cut method of mining and in a method using the minimum acceptable requirements as set forth in the present regulations has been prepared. The differential in costs of the two methods appears to be negligible. The demonstration will prove that the need for sediment basins with the modified block-cut method of mining will be minimized or perhaps eliminated, depending on future State and Federal requirements.

A water quality monitoring station will be constructed to provide data before, during, and after the mining operation. In this manner, the efficiency of this method of mining in providing onsite control of sedimentation may be fully evaluated and documented.

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The courtesies provided by personnel of the Division of Reclamation, Department for Natural Resources and Environmental Protection, Commonwealth of Kentucky, and particularly Ken Ratliff and Forrest Roark, have assured compliance with current regulations.

SECTION I

INTRODUCTION

In the past, the conventional method of strip mining in Eastern Kentucky involved the placement of overburden on the downslope, which caused significant water pollution problems downstream from the area being mined. Recent State legislation pertaining to strip mining (Kentucky Revised Statutes, Chapter 350) and regulations issuing therefrom (KAR 1:055 and KAR 1:060) effectively preclude the conventional method of strip mining since that method frequently causes excessive sedimentation and polluted water in public streams. Currently, much effort is being devoted to not only develop more effective sediment and pollution control devices, but also to devise alternate methods of conducting surface mining operations to significantly reduce sediment at the source. One such method being tested is the block-cut method, which has not been utilized extensively in Kentucky, but which has been applied beneficially in other states.

SCOPE AND PURPOSE OF THIS PROJECT

This project will demonstrate the ability of a modified block-cut method of surface mining to reduce the amount of sediment and water pollution resulting from strip mining for coal in a typical location in Eastern Kentucky. The quality of water runoff from a small, isolated, undisturbed watershed at the head of a small, seasonably flowing stream will be determined before the mining operation or other disturbances of the watershed surface or subsurface. The mining operation will then be conducted by a modified block-cut method, and the quality and quantity of water flowing from the mined area will be continuously monitored. Comparison of the water quality before mining operations will be made with the quality of water during and after mining to determine the water pollution effects of the block-cut method. Cost of mining operations using the conventional method will be compared with the cost using the block-cut method to determine the theoretical cost difference between the two methods and the cost effectiveness of reducing pollution by the block-cut procedure.

GENERAL DESCRIPTION OF THE PROJECT

The site for the demonstration is located in Perry and Letcher Counties in southeastern Kentucky at the head of Lower Lick Fork of Bull Creek, a contributary of the North Fork of the Kentucky River. There are 15.4 hectares (38 acres) in the site. Existing terrain is mountainous, with steep slopes and high ridges on each side of Lower Lick Fork. Vegetation is second growth timber. There has been no previous surface or deep-mine activity at the site.

The company leasing the mineral rights at the project site has agreed with the Kentucky Department for Natural Resources and Environmental Protection, Division of Reclamation, to use the block-cut method to extract coal. Instead of placing the first block in a head-of-hollow fill, the operator will modify the method of placing the first block in an orphan area outside the demonstration project watershed. The operator will then continue through the site using the modified block-cut method to mine the Hazard No. 7 coal seam.

Analysis of the quality of the water runoff from the site will be initiated before commencing mining operations. In fact, tests on water samples have been conducted since December 1974. A water monitoring station will be constructed on the Lower Lick Fork at the site boundary to continuously measure quantity of flow, temperature, and rainfall, and to periodically extract samples of water for analysis. Tests of water quality will be performed on the samples. A continuous record of water quality and quantity before, during, and after mining operations will be prepared and studied to determine the amount of water pollution resulting from the modified block-cut method.

A theoretical determination of time, equipment, sequence of operations, and cost requirements will be made for the modified block-cut method. This determination will be compared with a similar breakdown for the conventional strip mining methods so that the methods can be compared.

To complete the project, a comprehensive report will be prepared setting forth the findings of the demonstration project. Specific attention will be given to the water quality and sedimentation resulting from the use of the modified block-cut method of strip mining, both during the mining operation and afterward.

EFFECTIVENESS OF THE PROJECT

Application of the block-cut method of surface mining at producing mines has demonstrated the effectiveness of this method as compared to conventional methods of contour mining. The following advantages of the block-cut are reported by the U. S. Environmental Protection Agency:

1. Spoil on the downslope is totally eliminated. Since no fill bench is produced, landslides have been eliminated.

2. Mined area is completely backfilled, and since no highwall is left, the area is aesthetically more pleasing.

3. Acreage disturbed is approximately 60% less than that disturbed by conventional contour mining.

4. Reclamation costs are lower, as the overburden is handled only once instead of two or three times.

5. Slope is not a limiting factor.

6. The block-cut method is applicable to multi-seam mining.

7. At present, this method does not require the development of new equipment. As new mining technology develops, however, modified or new types of equipment may be needed.

8. Regular explosives are used, but blasting techniques had to be developed to keep short material on the permit area.

9. Bonding amounts and acreage fees have been reduced.

10. Size of the disturbed area drainage system is smaller.

11. Size and number of sediment control structures have been reduced. Total life of structure usefulness is increased.

12. No new safety hazards have been introduced. However, the increased number of pieces of moving equipment in a more confined area may negate this point.

13. Revegetation costs have been considerably reduced and it is easier to keep the seeding current with the mining. Bond releases are quicker.

14. AMD, siltation, and erosion is significantly reduced and more easily controlled because of concurrent reclamation with mining.

15. Total amount of coal recovered is equal to that recovered by conventional methods.

16. Overburden is easily segregated, topsoil can be saved, and toxic materials can be deeply buried.

17. Equipment, materials, and manpower are concentrated, making for a more efficient operation.

18. The method allows for early removal of equipment from the operation and placing it back in production at another site.

The disadvantages of the block-cut method were reported to be:[1]

1. Complicated and time-consuming methods of drilling and blasting to maintain control of the overburden and get proper fragmentation for the particular types of equipment being used in spoil removal.

2. Economics may limit use of this method; i.e., thin seams of stream coal cannot be recovered profitably if the overburden must be shot.

3. Special precautions must be taken in scheduling the various phases of mining and reclamation so as to realize the maximum recovery of coal and at the same time eliminate any dead time for equipment.

4. It is very important that the location of the initial box cut be properly selected. In some areas there will be no place to back haul the material taken at the beginning of the block-cut or to dispose of the excess spoil at the end of the operation. Head-of-hollow fill is not always possible, as it can only be done in a restricted set of circumstances.

5. Long-term environmental sequences are not known and will require a monitor program of a pilot block-cut operation to determine if stream siltation and mineralization can be eliminated.

6. Investment costs for spoil haulage equipment are increased. Some small mines cannot afford this additional expense.

7. The block-cut method develops no broad bench that has a high land use potential in mountainous terrain. No access is left for forest fire-fighting crews, timbering operations, or recreational purposes.

8. Augering must be conducted concurrently with mining.

It is obvious that the advantages outweigh the disadvantages and that the block-cut method is an effective mining procedure. If this proposed demonstration project is successful, it will produce findings that will eliminate disadvantage No. 5 from the above list since the purpose of this project is to set up a monitor program of a pilot block-cut operation. On the basis of experience from mining operations using the block-cut method, the effectiveness has been stated by Benjamin C. Greene,[2] West Virginia Reclamation Chief, to be, "As far as we're concerned it's the way of the future if we are to continue contour surface mining. . . . The environmental effects are very minimal and can be totally controlled by this mining method".

Public benefits ensuing from this project will be manifold and wide spread. Pollution created by contour strip mining and the cost of meeting water quality standards will generally be reduced. This will in turn increase the public use of water coming from strip mined areas for recreational, agricultural and industrial activity. The cost of treating public water will be reduced.

SECTION II

CONCLUSIONS

1. The sampling and testing process to date in Lower Lick Fork indicates the water quality to be essentially free from man made pollutants. The study area is therefore ideal for documenting the effectiveness of the modified block-cut method of mining in providing onsite control of sedimentation.

2. Initial calculations presented herein indicate the modified block-cut method of mining to meet Commonwealth of Kentucky Water Quality Standards for sediment yield without a silt basin. The fully documented demonstration project will prove that the need for silt basins will be minimized or eliminated assuming State and Federal regulations are not more stringent in the future.

3. The sediment yield from the actual mining operation utilizing the modified block-cut method of mining may be less than the sediment yield from the construction of a silt basin including access for construction equipment.

4. The disturbed area associated with the modified block-cut mining method is considerably less than methods utilized in the past. A comparison with methods utilizing minimum requirements provided by the recently approved Commonwealth of Kentucky Mining Regulations is included herewith. Depending upon the slope of the existing terrain, existing Kentucky requirements will require that a large percentage of the overburden be hauled back rather than placed on the outslope.

5. The sampling and testing program to be conducted as a portion of the demonstration project will document the relationship of disturbed area, slope, rainfall, and temperature to the generation of pollutants. Although the modified block-cut method of mining has been utilized in some states, the documentation of improvement in water quality has not been provided at this time.

6. The utilization of the modified block-cut method of surface mining will result in return of land to approximate original contour with provision of access road for fire-fighting, recreation, and wildlife trail. This method is pleasing to critics of surface mining.

7. Subsurface investigation of the project area indicated the coal thickness in some sections of the project area would not support augering operation. The operator indicated a willingness to strip this coal in order to support the goals of the demonstration project.

8. The permanent water quality monitoring station will provide all water samples necessary to evaluate the water quality of the upper reach of Lower Lick Fork before, during, and after mining.

9. One of the disadvantages of the block-cut method of mining listed in "Environmental Protection in Surface Mining of Coal" (EPA-670/2-74-093) was "Long-term environmental consequences are not known and will require a monitor program of a pilot block-cut operation to determine if stream siltation and mineralization can be eliminated". This demonstration project will correct this disadvantage.

10. Due to the relatively small size of the project area, calculations indicate that diversion ditches and vegetated fan outlets will not be required for onsite control of sedimentation.

11. The overall production costs utilizing the modified block-cut method of mining are comparable with methods meeting the minimum requirements of the Commonwealth of Kentucky regulations for surface mining.

12. The project will be in conformance with existing State law and will be regulated under the established authority of the Kentucky Department for Natural Resources and Environmental Protection.

SECTION III

RECOMMENDATIONS

1. Detailed pre-mining plans should be developed and be agreeable to all concerned parties and meet the requirements of State laws. These plans should be developed to allow for the most economical coal recovery, yet provide for the best control of sedimentation on the site.

2. Upon all approvals of the pre-mining plans a detailed field stakeout should be accomplished which will indicate the maximum area to be disturbed. Onsite inspection of the operation during mining will assure compliance with these goals, and will provide documentation of time, labor and equipment required to complete the operation.

3. Composite grab water samples should be tested weekly before, during, and for one year after mining. This will provide for evaluation of the effect of the mining and reclamation efforts upon water quality. Additionally, pollutographs should be developed based upon discrete water samples during rainfall events in order to accurately reflect relationship of flow, temperature, and pollutants.

4. Upon completion of mining, field surveys should be conducted to accurately define mined areas and drainage systems. Project pictures will be obtained twice monthly to record revegetation progress.

5. The operation should correct deficiencies in the available topsoil as indicated in the results of tests presented herein. The fertilizer and planting recommendations herein meet or exceed present Commonwealth of Kentucky regulations. Quick revegetation will also contribute to the effectiveness of onsite control of sedimentation.

SECTION IV

JURISDICTIONAL FRAMEWORK

COGNIZANT AUTHORITY

The authority for this study has been granted under the auspices of the Environmental Protection Agency by virtue of the "Federal Water Pollution Control Act Amendments of 1972", PL 92-500. Section 107 entitled "Mine Water Pollution Control Demonstrations" provides specific authority to conduct projects to demonstrate the engineering and economic feasibility of mine water pollution abatement techniques.

Administration of the study has been the responsibility of the Office of Planning and Research, an office within the Commonwealth of Kentucky's Department for Natural Resources and Environmental Protection, a statutory unit of the Kentucky state government headed by a Secretary appointed by the Governor. The Department has the authority to exercise all state functions providing for the conservation, maintenance and preservation of land and water resources and the prevention, abatement and control of all water, land and air pollution.

Powers of the Department for Natural Resources and Environmental Protection directly related to this study are authorized in Chapter 350 of the Kentucky Revised Statutes. The Department has authority to: adopt general rules and regulations pertaining to strip mining; to conduct hearings and investigations; to issue orders requiring remedial measures by mine operators; and to revoke permits.

Additional power to exercise general supervision, administration and enforcement of Chapter 350 are granted to the Secretary of the Department through the Division of Reclamation.

The Department's Division of Water Quality, Bureau of Environmental Quality, is charged with safeguarding the uncontaminated waters of the Commonwealth, preventing the creation of new pollution, and abating existing pollution in the waters of the Commonwealth. Authority, powers and duties of the Division of Water Quality as set forth in KRS Chapter 240, are adequate to fulfill the Division's responsibilities toward water quality as required by this study.

Legal authority also exists to cooperate with other agencies, including the Federal Government, to carry out any of the Department's functions and to receive federal and other funds as necessary to accomplish the purposes of the demonstration project.

EXISTING AND PROPOSED STANDARDS

Regulations and Standards have been adopted by the Department for Natural Resources and Environmental Protection to implement KRS Chapter 224 and Chapter 350. The KAR Regulations are administered by the Division of Reclamation. Water Quality Standards are administered by the Division of Water Quality. Existing standards insure that water emanating from surface mines will be of high quality and that sedimentation will be controlled. Regulations adopted July 2, 1975 are presented in 402 KAR 1:025 through 1:060. Since the project will be conducted under the direction of the Department for Natural Resources and Environmental Protection, the state agency charged with the implementation of KRS 350, all applicable regulations will be strictly observed. The agency has sufficient capability and authority to accomplish the surveillance and enforcement required by the project.

SITE ACQUISITION

The site selected for the project is located entirely within the State of Kentucky in Perry and Letcher Counties. Certicoals Incorporated has leased the surface and mineral rights for the site and has a legal right to conduct mining operations at the site, to permit the proposed demonstration project to be undertaken, and to give project personnel access to the site for the purposes of the demonstration. A letter setting forth Certicoals' Incorporated agreement to this effect is in the study files.

No other land, easements, condemnation, leases, or other access control techniques will be required for the proposed demonstration project, including the post-mining phase.

AUTHORITY FOR FUNDING

Federal funding for this project was provided by a grant to the State of Kentucky by the Environmental Protection Agency under Section 107 of the Federal Water Pollution Control Act, as amended. The grantee, under authority of KRS 350.163, is the Department for Natural Resources and Environmental Protection, Division of Reclamation. The Department is authorized to receive and accept Federal and other funds in accordance with KRS 350.163.

WATER AND MINERAL RIGHTS

Water and mineral rights and property ownership for the area designated as the site for the demonstration project present no problems for this project. No water will be diverted or used by the demonstration project. Water flowing in the one stream on the site will pass through the monitoring station with only small samples being periodically extracted for analysis. Therefore, water rights are not involved in the demonstration project. Mineral rights are leased by Certicoals Incorporated, the mining operator who will be cooperating with the Department of Reclamation in the demonstration project.

PREVENTION OF FUTURE POLLUTION

Under the KRS 350 the Department has developed standards and regulations to protect the people of the State from injurious effects of any strip mining operation. Water quality standards have been developed and are enforced (WP 7-1, Water Quality Standards for Waters of the Commonwealth of Kentucky). The laws and regulations of the State and the authority to enforce the laws and regulations as described above, stand as assurance that the area will not be affected adversely by the influx of acid or other mine water pollution from operations outside the project.

SECTION V

INVENTORY AND CHARACTERIZATION

PHYSICAL CONDITIONS

An investigation of sites suitable for this demonstration project was conducted by the Kentucky Department for Natural Resources and Environmental Protection and a site selected in Perry and Letcher counties in Southeastern Kentucky, near Cornettsville, Kentucky at the head of the Lower Lick Fork of Bull Creek. It appears on the USGS Vicco, Kentucky quadrangle map at approximately 37.1667° north latitude and 83.0417° west longitude. This site is shown on Figure 1 and Figure 2.

The existing terrain at the site is mountainous with steep slopes, averaging 24 degrees, and high ridges on each side of Lower Lick Fork. Existing vegetation in the project area is second growth timber, averaging approximately 250 mm (10 in.) trunk diameter. A narrow earth and rock access road links the residences along Bull Creek to Ky. Route 7 at Cornettsville. A logging trail connects the project site to this access road at the mouth of Lower Lick Fork.

A ground survey was made of the project area, and a topographic map was drawn to determine the physical characteristics of the site. Although mining activity is extensive in that area of Perry and Letcher Counties, no evidence was found of any previous surface or deep mine activity within the project area. There are several producing oil wells in the vicinity, the nearest being some 30 m (100 ft) in elevation below the coal seam.

Coal seams within the project area include the Hazard No. 7, Francis No. 8, and Fire-Clay #64 seams. It is presently anticipated, however, that only the No. 7 will be mined in this operation. A narrow "coal prospecting road" has been cut along the ridge contour to locate the Hazard No. 7 coal seam throughout the site. The bottom of this seam follows generally along the 510 m (1673 ft) contour and is approximately 1.0 m (3.4 ft) thick.

The site is a confined drainage area in which the proposed mining operation will be primary contributor to potential pollution of the receiving stream. This enables all sampling and testing of water quality to be conducted before, during, and after the mineral removal. The recommended site contains 15.4 hectares (38 acres) and all overland flow is directed into Lower Lick Fork. Except for prospecting trails, the site is in its natural state, and the sedimentation contribution from the prospecting trails is considered to be negligible. The project area is geographically in the path of low-pressure atmospheric formations that bear moisture and move from the western gulf region northeastward over the Mississippi and Ohio Valleys to

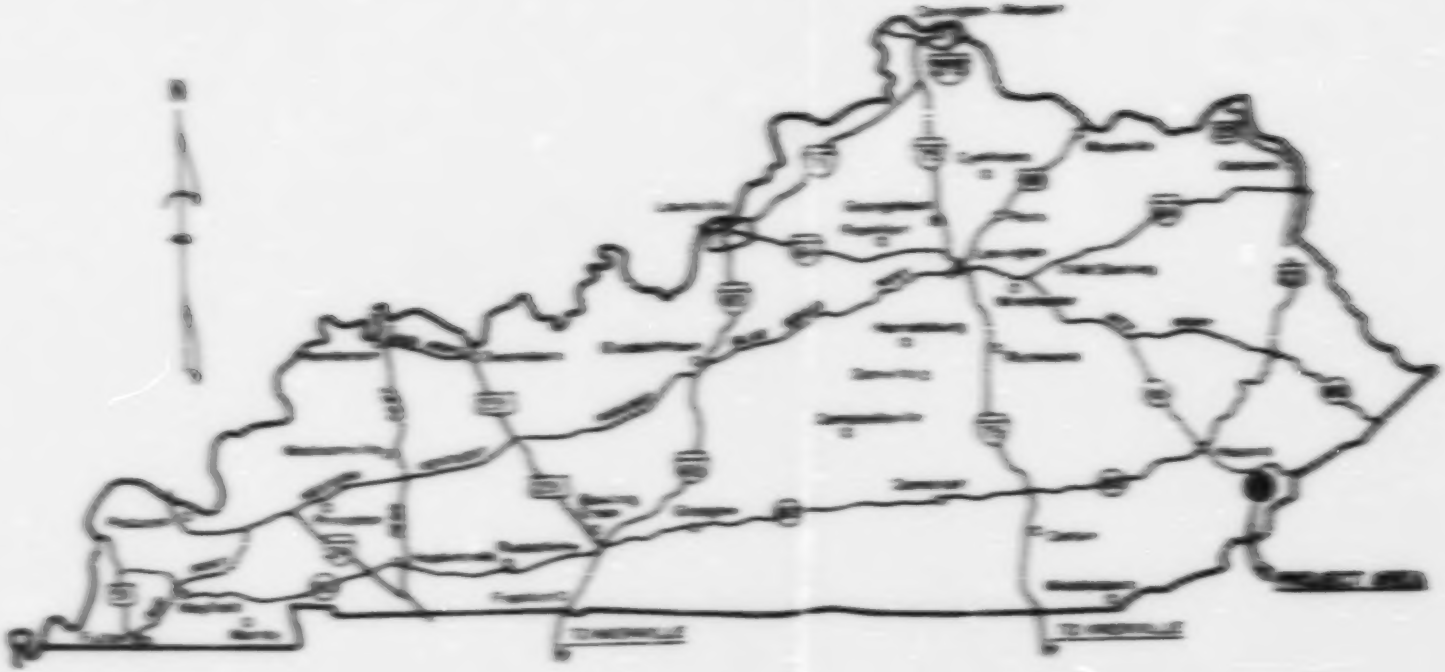


Figure 1. Project vicinity map.

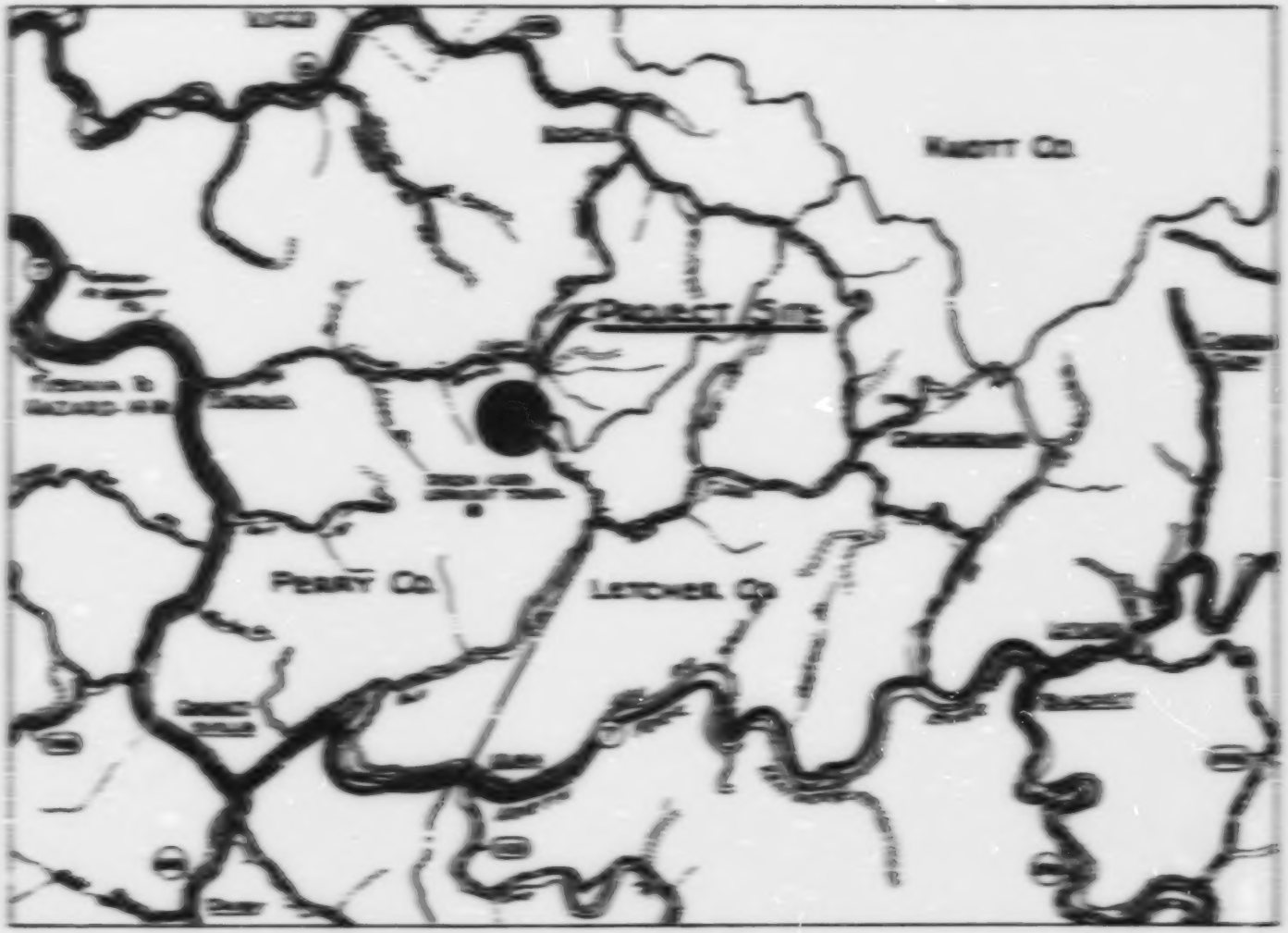


Figure 2. Project location map.

the Great Lakes and the northern Atlantic coast. In summer the temperature generally reaches, or slightly exceeds 38 C (110 F) but rarely for more than a few days. Temperatures around -18 C (0 F) occur with moderate frequency in December, January, and February, but long cold spells are always broken by intervals of moderate temperatures. This fluctuation in temperatures results in continuous freezing and thawing of the topsoil. The average date of the last killing frost in spring is about April 24, and that of the first killing frost in fall is about October 15. Length of the growing season is 175 to 180 days. Snowfall varies considerably from year to year, but annually averages about 510 mm (20 in.). The ground seldom remains covered with snow for more than a few days.

The site is in the Mountain physiographic region and on the western border of the Appalachian Plateau with underlying rock generally of the Pennsylvanian geologic age.

The approximate land area of Letcher County is 81,804 hectares (216,960 acres), and the area of Perry County is approximately 88,840 hectares (219,520 acres). The predominant land use in these counties is forest. Selected comparative land uses for the two project area counties for 2 years are shown in Table 1.

The table indicates approximately 86 percent of the total land area in Letcher County to be in forest use, with 85 percent of the total in Perry County similarly utilized. The "Other Land" category includes several miscellaneous uses, one of which is strip mines. It is significant that there was a decrease in area in both counties between 1958 and 1967 in this category. This indicates that the predominant use of land in Perry and Letcher Counties has historically been forest. It is anticipated that this usage will continue to dominate in future years. Although there is a considerable amount of surface mining in these counties, the "Other Land" category and the other categories do not approach the total area in forest.

The project area falls within the Shelocta-Jefferson-Wetkert Soil Association. A general description of this association is deep to shallow, well-drained soils on steep mountain sides. The landscape consists of very steep mountains dissected by the North Fork of the Kentucky River and its tributaries. Limitations for uses other than timber production are severe on the uplands because of very steep slopes, shallow depth, rock outcrops, and surface stone.

A Soil Conservation Service Survey indicated the Shelocta soils to comprise approximately 60 percent of this association while Jefferson soils and Wetkert soils were 20 and 10 percent respectively. Other soils in the remaining 10 percent included Barbourville, Allegheny, and Cotaco on the foot slopes and stream terraces; and Stendal, Pope, Philo, and Cuba along the streams.

It should be noted that the Shelocta and Jefferson soils are generally developed in colluvium, and the depth to rock is more than 1.2 m (4 ft.). Colluvium is soil material and/or rock fragments moved by creep or slide and deposited on the lower part of steep slopes. The subsurface investigation conducted as a part of this feasibility study indicates that the project area

TABLE 7. COMPARISON OF LAND USES

Adams County

Land Use Type	1950 Acres	1950 Percent	1960 Acres	1960 Percent	1967 Acres	1967 Percent
Urban Land Uses						
Residential	2,160	0.5%	2,960	0.7%	4,320	1.0%
Commercial	320	0.1%	440	0.1%	640	0.2%
Industrial	160	0.0%	220	0.1%	320	0.1%
Transportation, Communication, Utilities	1,280	0.3%	1,760	0.4%	2,560	0.6%
Total Urban Land Uses	3,920	0.9%	5,380	1.3%	7,840	1.9%
Rural Land Uses						
Cropland	320,000	76.2%	315,000	75.0%	310,000	73.8%
Pasture	60,000	14.3%	58,000	13.8%	55,000	13.1%
Forest	30,000	7.1%	28,000	6.7%	26,000	6.2%
Other Rural	6,080	1.4%	13,620	3.2%	21,160	5.0%
Total Rural Land Uses	416,080	99.1%	414,620	98.7%	412,160	98.1%
Total Land Area	420,000	100.0%	420,000	100.0%	420,000	100.0%

Source: Adams County Planning Department, Land Use Inventory, 1950, 1960, and 1967.

soils are generally within the Shelocta group. This is based upon the depth to rock and the fragments in the soil coverage. General geological information regarding the project area may be obtained from the "Geology of the Vicco Quadrangle, Kentucky" developed in 1965 by the Kentucky Geological Survey. This document indicates the project area to be in the Pennsylvanian outcrop, which in Kentucky is similar in both the Eastern and Western Coal Fields.

The mining operation associated with this feasibility study will remove the Hazard No. 7 coal from the project area. Field surveys indicate the coal to outcrop at approximate elevation 510 m (1673 ft) through the area to be mined, and the top of the ridge within the project area to range from 554 to 587 m (1818 to 1927 ft) in elevation. The Vicco Quadrangle indicates another seam, the Francis, to lie above the No. 7 within this vertical range. This seam (also known as the No. 8) has not been extensively mined in the general area reportedly due to erratic thickness and shale partings several feet thick. A general geologic description of the project area, taken directly from the Vicco Quadrangle publication is as follows:

> Sandstone, siltstone, shale, and coal: Sandstone, light-gray, weathers yellowish brown; fine-to medium grained; micaceous, locally argillaceous; firmly cemented, friable on weathered surfaces. Siltstone and shale, light-gray and medium-gray; plant fossils common on bedding planes. Entire unit poorly exposed; forms steep slopes with narrow benches on tops of sandstone units. Coals, generally thin, occur in most shale zones but only two are persistent laterally. The Francis coal zone consists of one or more coal beds and black shale; shale partings are as much as one meter (several feet) thick. The Hazard No. 7 coal bed is persistent throughout the area and commonly has sandstone roof rock; a rider coal bed as much as 559 mm (22 in.) thick occurs from 0.3 to 3 m (1 to 10 ft) above the Hazard No. 7 coal bed where roof rock is shale.

Logs of the core borings are included in Appendix A. The mountain slopes are covered by a soft, brown, silty clay with sandstone fragments throughout. This overburden extends to depths from 1.5 to 2.0 m (5 to 7 ft) below the ground surface. Beneath the overburden is a hard massive sandstone which is mostly micaceous. The first 1.5 to 3.0 m (5 to 10 ft) of sandstone is slightly weathered and characterized by its yellowish-brown color. Thin layers of irregularly bedded clay separate the weathered sandstone from a coarse-grained, light gray sandstone which extends to an approximate depth of 512 m (1,680 ft). The rock material beneath the sandstone and overlying the coal seam varies distinctively throughout the site. In various locations, the massive, gray sandstone extends and directly overlies the coal seam. However, more commonly the stratum above the coal seam is a coarse-grained, micaceous sandstone changing gradually to a hard, gray, shaley siltstone. Shale is also found overlying the coal and is characterized by its dark gray, hard texture.

Brittle, bituminous coal characterizes the coal seam material which varies in thickness from 0.9 to 1.5 m (3 to 5 ft). Throughout the site, dark gray underclay and hard shale underlie the coal seam.

WATER RESOURCES

The project area is located within the Kentucky River drainage basin. Activities will be at the head of Lower Lick Fork, a tributary of Bull Creek, which discharges into the North Fork of the Kentucky River near Cornettsville. The North Fork joins the main stem of the Kentucky River at Beattyville in Lee County, and the Kentucky River ultimately discharges into the Ohio River. Stream flow in the Lower Lick Fork is seasonal and subject to non-flow periods during dry months. Data based on U.S. Geological Survey information indicates that measurable precipitation in the project area may be projected to occur on approximately 140 days annually, with total annual precipitation averaging 1150 mm (45.28 in.) "Estimated Point Rainfall Values" and "Long-Term Averages of Temperature and Precipitation in Eastern Kentucky" are shown in Tables 2 and 3 respectively.

TABLE 2. ESTIMATED POINT RAINFALL VALUES FOR PERRY-LETCHER COUNTIES*

Duration	Frequency (Years) 1		2		5		10		25		50		100	
	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.
30 min.	23	0.9	28	1.1	36	1.4	43	1.7	48	1.9	53	2.1	58	2.3
1 hr.	31	1.2	36	1.4	46	1.8	53	2.1	61	2.4	69	2.7	76	3.0
2 hr.	36	1.4	43	1.7	56	2.2	64	2.5	74	2.9	81	3.2	89	3.5
3 hr.	38	1.5	48	1.9	58	2.3	71	2.8	81	3.2	86	3.4	97	3.8
6 hr.	48	1.9	58	2.3	71	2.8	81	3.2	97	3.8	104	4.1	117	4.6
12 hr.	58	2.3	69	2.7	84	3.3	96	3.7	109	4.3	122	4.8	137	5.4
24 hr.	64	2.5	76	3.0	97	3.8	109	4.3	127	5.0	140	5.5	152	6.0
2 day			86	3.4	107	4.2	125	4.9	145	5.7	163	6.4	178	7.0
4 day			101	4.0	127	5.0	147	5.8	170	6.7	191	7.5	203	8.0
7 day			117	4.6	142	5.6	168	6.6	201	7.9	216	8.5	239	9.4
10 day			132	5.2	165	6.5	183	7.2	224	8.8	241	9.5	264	10.4

*Data selected from Kentucky Department for Natural Resources, Division of Water, Engineering Memorandum No. 2 (4-30-71).

TABLE 3. LONG-TERM AVERAGES OF TEMPERATURE AND PRECIPITATION IN EASTERN KENTUCKY*

Month	Temperature: °C	°F	Precipitation: mm	in.
January	3.7	38.6	116.6	4.59
February	4.3	39.7	97.8	3.85
March	8.3	46.9	124.7	4.91
April	13.7	56.6	90.9	3.58
May	18.4	65.2	101.3	3.99
June	23.0	73.5	107.6	4.24
July	24.7	76.4	117.9	4.64
August	24.0	75.2	98.6	3.88
September	20.8	69.4	67.1	2.64
October	14.6	58.3	56.4	2.22
November	7.8	46.1	80.3	3.16
December	3.7	38.7	90.9	3.58
Year	13.9	57.1	1150.1	45.28

*Data selected from U.S. Dept. of Agriculture, Reconnaissance Soil Survey, Fourteen Counties in Eastern Kentucky, Series 1962, No. 1 (2-65).

The project area is a confined watershed of approximately 15.4 hectares (38 acres). There are no known existing streamflow data on Lower Lick Fork. Likewise, no data exist for the Bull Creek drainage area which receives runoff from Lower Lick Fork. However, rainfall intensity records do exist for this section of the Commonwealth of Kentucky. Anticipated streamflows at the terminus of the study area for 2-year and 100-year peak rainfall intensities have been calculated. The results of these calculations utilizing the Rational Formula indicate a 2-year peak rate of flow of 0.93m³/s (33 cfs) and a 100-year peak rate of flow of 2.97m³/s (105 cfs).

The character of the surface water within the project area has been sampled and tested weekly since the notice to proceed was granted. Generally, this mountain stream is clear and virtually free of impurities. Results of all of these tests are included in Appendix B of this report. After testing the first 64 samples, the range for the various tests is as follows:

pH	5.4 to 7.7
Specific Conductance	24 to 4500 micromhos
Turbidity	7 to 84 NTU
Hardness (total)	7.4 to 195.0 mg/l
Alkalinity	2.6 to 30.1 mg/l
Acidity	2.1 to 15.6 mg/l
Iron	<0.01 to 3.78 ppm
Calcium	0.80 to 33.00 mg/l
Magnesium	0.96 to 23.00 mg/l
Manganese	<0.01 to 1.82 mg/l
Suspended Solids	0.4 to 43.6 mg/l
Settleable Solids	<0.1 to 10.0 mg/l
Sulfate	<1.0 to 186.0 mg/l

Source: Project area sampling and testing results, Lower Lick Fork, Watkins and Associates, Inc.

Although there is not a full-record gauging station in the immediate environs, a partial-record gauging station has been maintained by U.S.G.S. near Cornettsville. This station is located at the L & N Railroad Bridge, 85 m (280 ft) downstream from Leatherwood Creek and 960 m (3,150 ft) southwest of Cornettsville, and gauges a drainage area of 834 km² (322 square miles).

Discharge measurements and selected water quality tests are performed during the water year at low-flow dates. A comparison of data collected at this station for selected dates in 1970, 1971, and 1972 is shown in Table 4.

These data are reported to indicate the variances that have existed on the dates during which the samples have been obtained at the Cornettsville gauging station. The Cornettsville pH factors ranging from 7.5 to 8.4 for the three dates do not indicate acid water. The "Kentucky Framework Water Plan" published in October, 1971, by the Commonwealth of Kentucky, Department for Natural Resources, Division of Water, contains a plate indicating that

Cornettsville reach of the North Fork of the Kentucky River is intermittently affected by mine drainage (Figure 10, in the "Water Plan")[3]. Although there is a potential for acid mine drainage within this area, it does not appear to be a significant problem at this time.

TABLE 4. SELECTED WATER QUALITY DATA, CORNETTSVILLE GAUGING STATION, NORTH FORK OF KENTUCKY RIVER

Description	9/17/70	10/19/71	8/17/72
Discharge (m^3/s)	0.25	1.54	0.67
Bicarbonate (mg/l)	126	120	128
Carbonate (mg/l)	--	0	5
Dissolved Sulfate (mg/l)	168	170	200
Dissolved Chloride (mg/l)	10	6.3	9.2
Dissolved Fluoride (mg/l)	0.2	--	--
Nitrate (mg/l)	1.0	0.1	0.2
Total Phosphorus (mg/l)	0	0.02	0.04
Dissolved Solids (mg/l)	364	366	424
Hardness (mg/l)	208	200	230
Non-Carbonate Hardness	105	100	120
Specific Conductance (micromhos)	589	536	638
pH	7.6	7.9	8.4
Temperature (°C)	25	18	25.5

Source: Water resources data for Kentucky, U. S. Department of the Interior, Geological Survey, 1970, 1971, and 1972.

The significance of the water quality analyses presented herein may also be emphasized by the Water Quality Standards for Waters of the Commonwealth of Kentucky. The North Fork of the Kentucky River is utilized for public water supply at Hazard, 24 km (15 miles) downstream from Cornettsville and is classified by the Commonwealth of Kentucky as a public water supply and must meet their standards.

The comparison of the analyses obtained at the Cornettsville gauging station with Kentucky Water Quality Standards and with the criteria recommended by others for the various tests leads to the conclusion that the North Fork of the Kentucky River has met and continues to meet standards for public water supply.

Tests on water samples taken at Lower Lick Fork within the project area have been compared with the recommended criteria for public drinking water supply. Based upon this comparison and the test results to date, the existing water quality in Lower Lick Fork is within the criteria for public drinking water supply.

The major problems associated with the mining operation in the project area are anticipated to be predominantly erosion and sedimentation. Sediment production from strip mined areas has been found to be influenced by many factors, the most important factors are the location and placement of spoil material; amount of disturbed area; haul road maintenance; location and

drainage; and elapsed time to revegetation. In the proposed demonstration project, all of these factors will be carefully controlled through premine planning. The exposed area will be less than half of that produced by conventional mining. The spoil placement will be controlled so that the most fertile and least polluting material is placed on top. The spoil areas will be seeded on a two-week schedule when weather permits so that no spoil will be in place more than two weeks before it is seeded. Mulching will be practiced as needed. All spoil slopes will be much shorter than those resulting from conventional surface mining. They will also have designed drainage so that gulley formation will be controlled. All drainage from the spoil will be collected in drainageways constructed next to the haul road at the point where the coal outcrops. These drainageways will outlet under the haul road through culverts into existing natural draws. The drainageways themselves and their outlets will be constructed so as to encourage sediment to deposit before entering the main water course. Haul roads will be drained through the same drainage system as for the spoil material. Haul road slopes will be minimal since they will run along the coal outcrop. Haul roads will be maintained to prevent gulley erosion. A minimum of vegetation will be disturbed in the study area during the mining operation with no disturbance occurring above the highwall or below the haul road. A border of vegetation and forest litter will protect the main stream from sediment by serving as a sediment filter.

It is thought that by careful consideration of all of these details, the sediment that will be produced from the demonstration project will be many times less than that produced from conventional, contour strip mining. It is anticipated that sediment production from annual storms will be nearly completely controlled. Only relatively severe rainstorms with return periods of 5 years or more will produce significant quantities of sediment attributable to surface mining in the project area.

SOCIAL AND ECONOMIC ENVIRONMENT

The socio-economic history and potential of Eastern Kentucky is deeply rooted in the coal industry. Out migration has recently been a primary problem in these counties as the coal mining industry cannot, in itself, provide employment to all potential employees. This fact, along with the lack of adequate industrial employment in the area, has resulted in many young people leaving Eastern Kentucky to seek employment elsewhere as seen in the population trends for Letcher and Perry Counties in Table 5.

TABLE 5. POPULATION TRENDS, PERRY AND LETCHER COUNTIES

Year	Population of Perry County	Population of Letcher County
1910	11,255	10,623
1920	26,042	24,467
1930	42,186	35,702
1940	47,828	40,592
1950	46,566	39,522
1960	34,961	30,102
1970	25,714	23,165

Source: U.S. Census of Population, 1910-1970.

Population projections vary considerably for Perry and Letcher Counties. Improved transportation facilities, the increasing demand for coal, the recognition of coal as an answer to our national energy problems, and the possible interest of industry locating in the area should all be considerations in these projections. Two sources of projections which indicate variations are the Kentucky Population Projections, 1975-2000, published in 1972 by the Kentucky Program Development Office, and the projections developed by the Kentucky River Area Development District for use in the Comprehensive Water and Sewer Program completed in 1971. These projections, designated as A and B respectively, are as follows:

TABLE 6. POPULATION PROJECTIONS,
PERRY AND LETCHER COUNTIES, 1975 to 2000

	Perry County		Letcher County	
Year	Projection A	Projection B	Projection A	Projection B
1975	25,140	27,110	22,446	23,224
1980	25,441	28,077	21,627	23,775
1990	22,405	29,211	19,487	24,598
2000	20,155	30,743	17,065	25,229

Sources: Projection A - Kentucky Population Projections, 1975-2000
Projection B - Kentucky River ADD Comprehensive Water-Sewer Program

These totals are indicative of the ranges encountered in various projections of future population in Eastern Kentucky. (Changing conditions can result in downtrends or uptrends originally not anticipated.) Projection B shows gradual growth in the two counties while Projection A indicates a gradual decline. The differential in year 2000 between the two projections is 18,742 people in the two counties. Perhaps the best indicator of the accuracy of the projections may be found in the "provisional" population estimates for 1974 developed through the Federal-State Cooperative Program. These estimates indicate 1974 populations of 27,600 in Perry County and 25,100 in Letcher County. These estimates are well above the anticipated population for 1974 in both projections. This is apparently indicative of the high demand for coal and increasing employment opportunities in these counties.

Economic forecasts indicate that industrial growth in Kentucky will increase at an accelerated rate during the next several years. Predominant factors include the abundant waterways and the accessibility to coal supplies. Other prevalent conditions which favor industrial development in Kentucky include lower land and development costs and availability of labor. This increase in industrial development will stimulate increases in urbanization in Kentucky; therefore a greater demand will evolve from both industry and municipalities for a higher quality water supply source. Virtually all municipal and many industrial water supplies, regardless of their source, must be treated in some manner before use. Increasing costs of treatment of natural water supplies before use is rapidly becoming a major problem faced

by all potential users of Kentucky's water resources. The continued high demand for coal to meet current and future energy needs should stimulate great surface mining activity within the Kentucky coal fields, thereby increasing the potential sources of sedimentation and acid pollution from surface mines to the water resources of the Commonwealth. Therefore, it is essential that every feasible means of maintaining or improving the quality of Kentucky's water resources be advanced so that a sufficient quantity of good quality water will be available for existing and potential user consumption. Therefore, the demonstration of onsite control of surface mine sedimentation will provide valuable guidelines for the implementation of methods to control sediment production.

ECONOMY

The relationship of economic conditions in Perry and Letcher Counties with the coal industry can best be indicated by total personal income and per capita income. Data compiled by the Office of Business Development and Government Services, University of Kentucky, indicate a steady growth in both counties even though they are still below the statewide average, but the condition has been improving more rapidly in the study area than statewide. The 1969 per capita income in Perry County was 62.38% of the statewide average while in 1973 the per capita income increased to 80.07%. For the same two years in Letcher County, the percentages were 64.25 and 74.86 respectively. Although the 1974 data has not been compiled, it is anticipated that the per capita income will increase due to the coal demand for that year.

The U.S. Department of Commerce has compiled data reflecting the total personal income from the mining industry in all Kentucky counties. When this data is compared with the income from all sources in the study counties, it was determined that in 1972 about one-third of the personal income in Perry County was attributable to the mining industry while almost one-half of the personal income in Letcher County came from mining. The non-mining employment in professional services, business service, and other related services, would also be dependent upon mining employment.

The Kentucky Department of Economic Security publishes annual employment and unemployment averages for all Kentucky counties. For the past few years, the unemployment rate in Perry and Letcher Counties has been above the statewide average. These estimates also indicate very few jobs available in the two counties in agricultural and manufacturing categories.

The continuation of coal mining activities is obviously extremely important to the social and economic environment in Perry and Letcher Counties. This project is expected to demonstrate an improved method of surface mining that is more compatible with the environment, is economically feasible, and is conducive to increased coal production.

SECTION VI

PRELIMINARY ENGINEERING

ABATEMENT METHOD DESCRIPTION

This demonstration project will utilize a modified block-cut method of surface mining for onsite control of sedimentation. The project area is a confined watershed with essentially no man-made environmental pollution characteristics. The only disturbance presently within the area is trails developed by bulldozers during prospecting. The sedimentation increase from these trails is considered negligible, and base data on the water quality of Lower Lick Fork has been obtained since commencing the feasibility study. In this manner, the changes in water quality during and after mining can readily be obtained. A monitoring station will be constructed in the project area prior to commencing mining.

This project will predominantly address the sedimentation problem associated with surface mining. Published reports indicate that the placement of overburden on the outslope is the largest single source of sedimentation from surface mining. The methods of mining primarily utilized in past years in Eastern Kentucky have resulted in overburden on the downslope, and hence sedimentation problems.

The utilization of the block-cut method of mining has been very limited in Kentucky to date. Other states have experienced beneficial results from this mining method; and West Virginia operators have been utilizing a similar method called "controlled placement" since 1973. The mining company which is cooperating with us on this demonstration, and which will be accomplishing the actual mining and reclamation, has utilized the "controlled placement" method in its work in West Virginia.

The initial cut in the block-cut method presents problems in some operations. The overburden from the first cut is placed on the outslope, in a head-of-hollow fill, or in some other appropriate location. In this demonstration project, this program will not exist as the material will be hauled back to an orphan area outside the demonstration project watershed. This will provide a desirable situation insofar as the control of overburden is concerned.

The first activity in the project area will be cutting a trench along the coal outcrop line to catch rolling stones. Timber will then be removed within the limits of the proposed excavation. Topsoil will then be stockpiled along the bench for use in final grading. There are approximately

8.9 hectares (22 acres) of wooded drainage area above the anticipated location of the highwall. Due to the runoff characteristics and size of area, diversion ditches above the highwall are not deemed necessary.

After the timber is removed, a drill bench will be excavated with a bulldozer. All material from the drill bench will be stored upslope from the trench, or removed to the previously mined area. The remaining material will then be shot in accordance with the blasting plan. The operator's blasting crews are experienced in maintaining control of overburden and obtaining proper fragmentation.

The overburden will be then hauled back to areas previously mined, and the land returned to approximate original contour. The final bench width basically will be the haul road which will be left in place for fire fighting access. The final grading plan in the demonstration area is contained elsewhere in this feasibility study.

During the mining operation, a barrier will be maintained at the intersection of the top of coal and the existing terrain. No coal is to be removed for a distance of 4.6 m (15 ft) toward the highwall from this intersection. This will minimize the runoff from the mined area, and the area comprising a portion of the haul road. The coal will be removed from the open pit and then augered along the highwall prior to backfilling. In backfilling areas, the haul road will be maintained for removal of the mineral.

Curtis[4] observed from measurement of sediment accumulation in debris basins that post-disturbance sedimentation from areas of strip mining activities has an approximate half-life of six months. Most of the resulting sedimentation due to mining activities occurs during the first six months following initial disturbance. By utilizing the modified block-cut method, the disturbed area is minimized and the time of exposure of the unvegetated material is shortened. This concept is therefore anticipated to reduce production of sediment load from the mining operation.

ANALYSIS OF ADDITIONAL OPERATOR COSTS DUE TO PROPOSED MINING METHOD

Kentucky regulations for the coal mining industry set forth minimum requirements which must be met in recovery of coal by strip mining. Conclusions drawn from the results of this demonstration project must be based upon not only the degree of sediment control projected by the proposed project but also the estimated additional costs of implementing those mining methods which exceed the minimum requirements of the regulations. Since overburden removal and regrading is one of the major costs involved in strip mining, it is desirable to estimate the cost of overburden handling per unit weight of coal uncovered utilizing the proposed project mining method. This cost may then be compared to the estimated cost per unit weight of coal uncovered by meeting only the minimum requirements for equivalent volumes of overburden handling and coal recovery. This comparison may then be expanded to include costs per unit weight of coal yield (stripping plus augering). Permit costs

may be estimated for each method based upon requirements specified in the revised regulations. Revegetation costs may be estimated and compared based upon costs per unit over the area disturbed by each method.

The average downslope (measured at the point of outcrop of the top of the coal seam with the original ground line) on this project was determined to be 24° ±. This value was obtained in the manner specified by the revised regulations which is required for permit applications, with the exception that slopes were computed for each 30 m (100 ft) of outcrop contour. Based upon this "average downslope" a composite cross-section was selected from actual survey cross-sections and is shown in Figure 3. This composite cross section was utilized for estimating the amounts of overburden to be handled for this project using minimum regrading and reclamation requirements, and complying with all maximum bench and slope requirements.

From this average cross-section it was determined that:

1. 9% of all overburden material could be left permanently on the regraded outslopes.

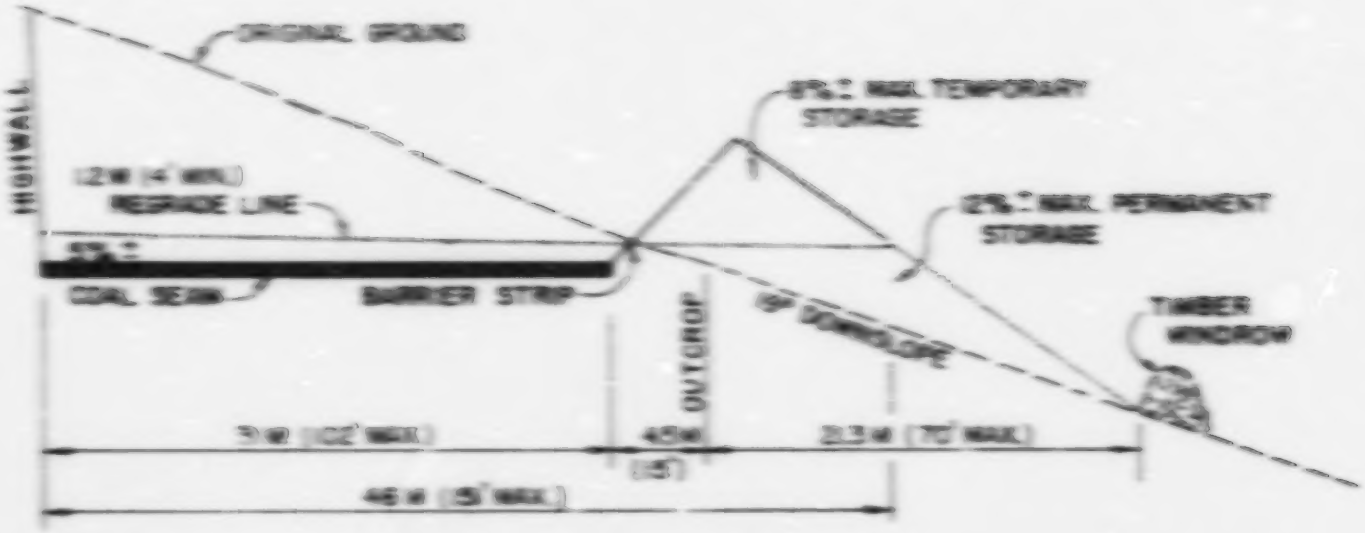
2. 22% of all overburden material must be returned to the mined-out pit.

3. 2% of all overburden material (predominantly upper level soils) must be stacked on the outslope fill bench and then regraded and used for "topping out" the backfill regrading. (double handling)

4. 67% of all overburden must be "end-hauled" to a suitable permanent storage location using methods similar to those employed by the proposed project mining method.

From these percentages a comparative estimate of costs incurred per cubic yard of overburden handled was developed. It was assumed that the cost per cubic yard of overburden to be end-hauled to a suitable off-bench location for permanent storage would be the same for both the partial end-haul method used to satisfy minimum requirements, and the total end-haul method to be used in this project. This cost is based on an average haul distance of 150 m (500 ft) for each method. Assuming that an efficient combination stripping and augering operation requires approximately 150 m (500 ft) of open bench working length regardless of the overburden handling method, then it may also be assumed that the average 22% of all overburden material required by regulation to be returned to the mined-out pit as back-fill would also be end-hauled a distance of 150 m (500 ft).

It was further assumed that the 9% of the overburden to be permanently deposited on the fill bench and outslopes would be moved by bulldozing down an average grade of 20%, an average distance of 30 m (100 ft). Since the revised regulations require that upper level soils be stockpiled and used for final grading regardless of the mining method, the 2% regraded from the



15° DOWNSLOPE

Figure 3a. Selected project area downslopes and a composite cross section to meet minimum requirements only.

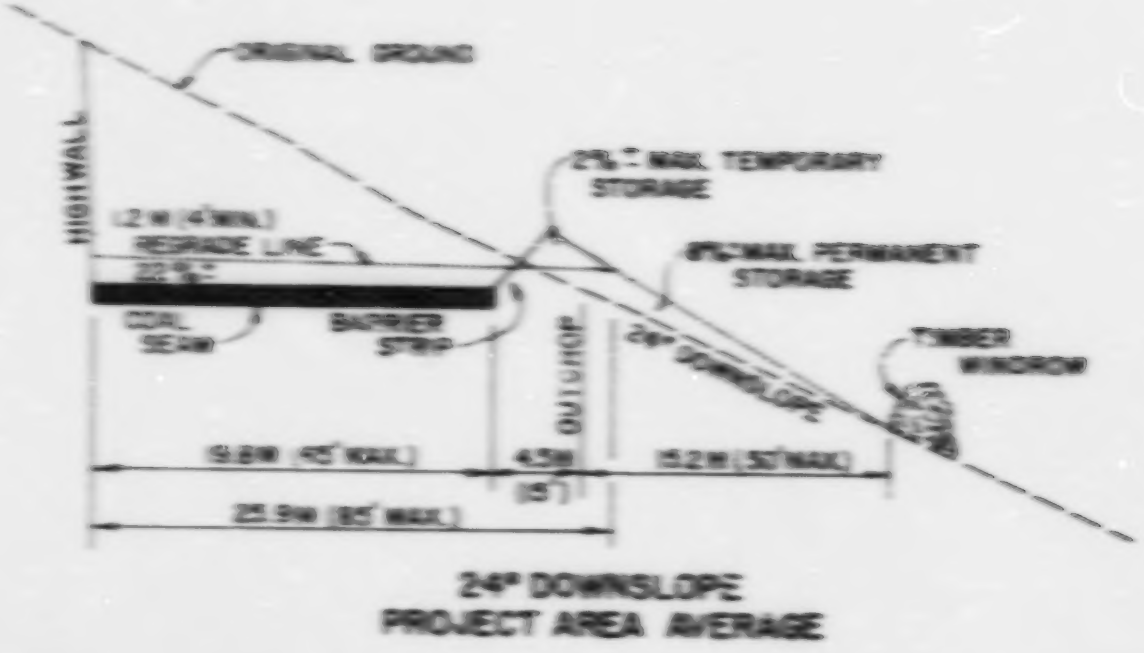


Figure 3b. Selected project area downslopes and a composite cross section to meet minimum requirements only.

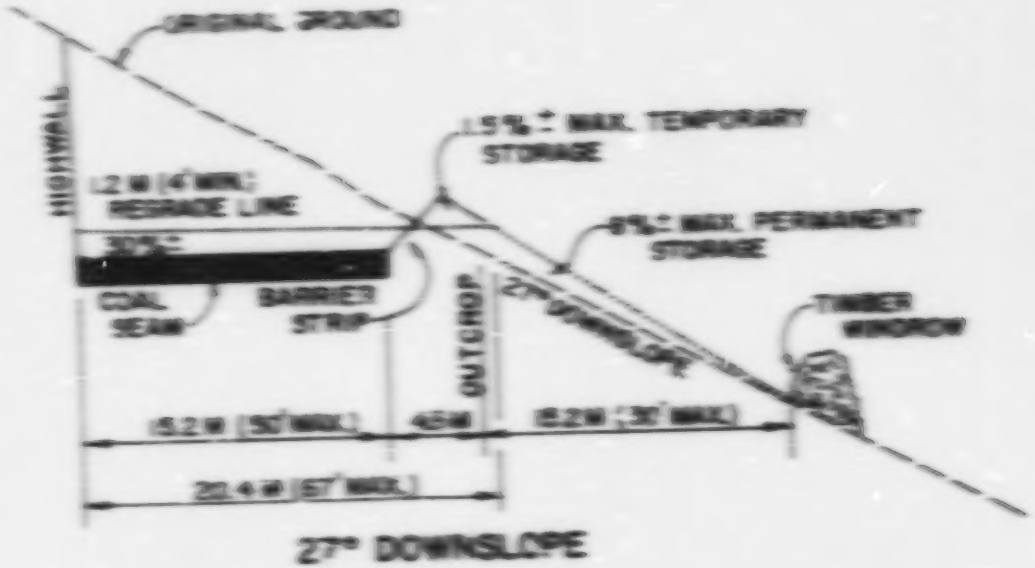


Figure 3c. Selected project area dimensions and a composite cross section to meet minimum requirements only.

fill bench would also apply to both methods. Thus 2% would be bulldozed down an average grade of 80%, an average distance of 30 m (100 ft) and stacked on the fill bench. For final dressing this material would be end-hauled back onto the regraded working bench an average distance of 150 m (500 ft). Figure 4 shows the measured downslopes within the project area. Also shown are the mining operations permitted based upon the slope requirements of the revised regulations. These requirements specify that areas where the downslope exceeds 27° may only be augered since no overburden can safely be stored on slopes steeper than 27°. However, the regulations do permit both stripping and augering of slopes over 27° if the total end-haul method of mining is utilized. It is assumed, therefore, that small areas which would ordinarily be deleted from the mining plan due to slope restrictions would be stripped and augered using total-end-haul methods since a high percentage of end-haul is required regardless of the method used.

Any meaningful comparative cost analysis must be based upon equal lengths of seam to be stripped, equal volumes of overburden to be moved, equal tons of coal recovered, and equal overburden-to-coal recovery ratios. Therefore, the estimated overburden removal and coal recovery volumes from the proposed project mining method have been used in computing cost estimates for both methods. The percentages of overburden allowed to be placed on the outslopes (either temporary or permanent, derived from the average cross section discussed earlier) were applied to the total-end-haul method volumes only through the areas having downslopes of 27° or less. Other areas were computed using total-end-haul. Areas too close to the stream bed to be stripped under the revised regulations were also assumed to be stripped using total-end-haul.

The swelled volume of overburden to be removed for the proposed mining method (total-end-haul) is 127,540 m^3 (166,800 cy). The weight of coal to be recovered by stripping is 17,690 megagrams (19,500 tons). These amounts were estimated utilizing actual surveyed cross sections and drilling logs within the project area. The estimated length of highwall to be augered is 416 meters (1,365 ft). The expected coal recovery due to augering (average 28" diameter auger holes extending 46 m (150 ft) into the seam at the highwall) is 11,700 megagrams (12,900 tons). Total coal yield for the project area is estimated to be 29,393 megagrams (32,400 tons), and the estimated overburden to coal recovery ratio is 5.2 to 1.

The above volume of overburden removal will be accomplished using total end-haul for the project mining method. However, if the revised regulations are applied to the same volume of overburden and only the minimum requirements are met, then the mining operations and overburden volumes corresponding to the areas of Figure 4 are as shown in Tables 7 and 8.

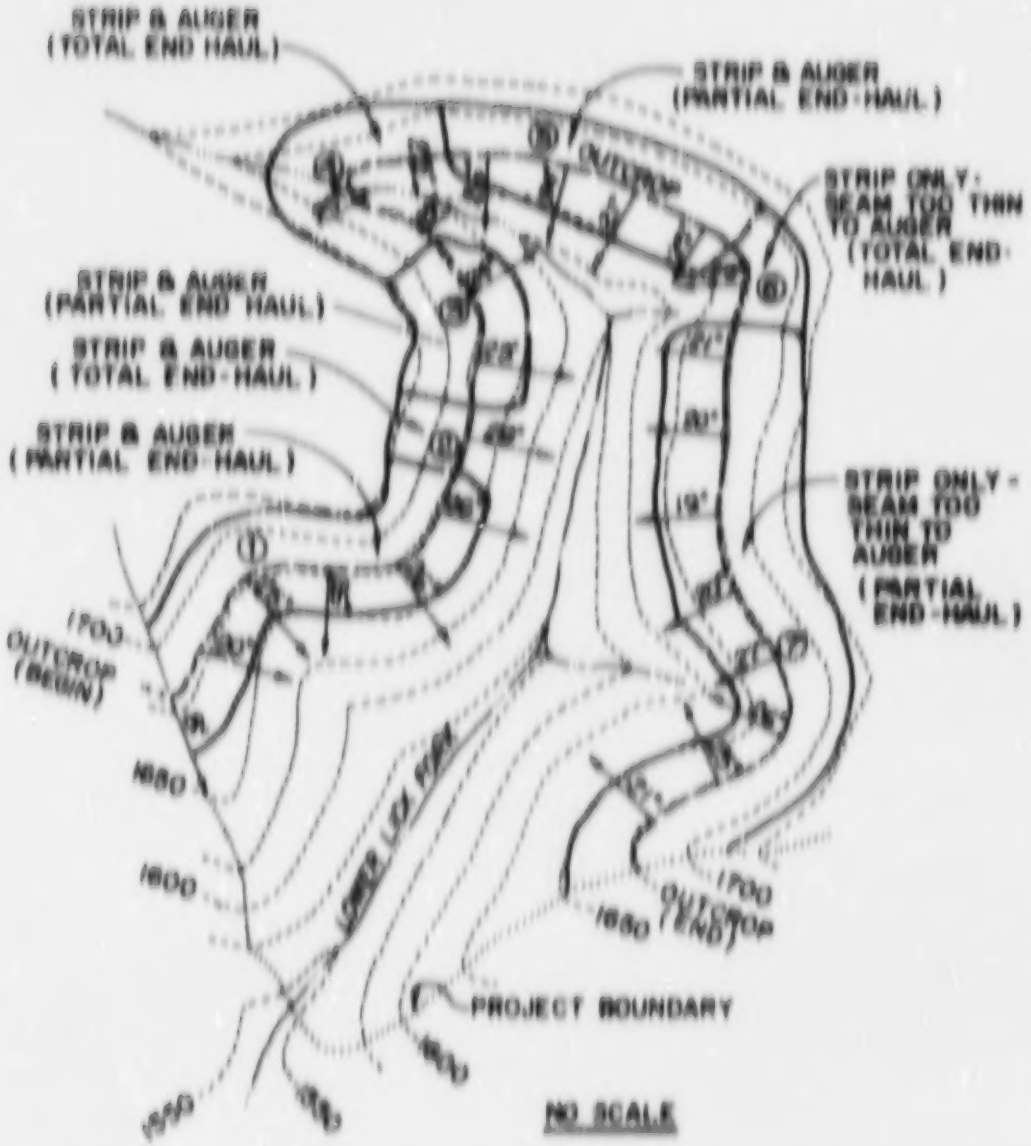


Figure 4. Project area downslopes and mining methods to meet minimum requirements only.

TABLE 7. OPERATIONS PERFORMED AND OVERBURDEN REMOVAL METHODS TO MEET MINIMUM REQUIREMENTS ONLY

Area	Operations performed	Overburden removal method
1	Strip and auger	Partial end-haul
2	Strip and auger	Total end-haul
3	Strip and auger	Partial end-haul
4	Strip and auger	Total end-haul
5	Strip and auger	Partial end-haul
6	Strip only*	Total end-haul
7	Strip only*	Partial end-haul

*The coal seam within areas 6 and 7 is considered by the operator performing the mining to be too thin to be augered or stripped economically. However, the operator has agreed to strip these two areas in order to maintain the integrity of this demonstration project.

TABLE 8. OVERBURDEN VOLUMES NECESSARY TO COMPLETE PROPOSED PROJECT MINING MEETING ONLY MINIMUM REQUIREMENTS

Area	Overburden to remove m^3	Overburden to be end-hauled m^3	Permanent overburden storage on outslope m^3	Temporary overburden storage on outslope m^3	Overburden to be bulldozed m^3
1	27,100 (35,400)*	24,600 (32,200)	2,500 (3,200)	500 (700)	2,900 (3,900)
2	6,200 (8,100)	6,200 (8,100)	0 (0)	200 (200)	200 (200)
3	13,500 (17,700)	12,300 (16,100)	1,200 (1,600)	300 (400)	1,500 (2,000)
4	15,200 (19,900)	15,200 (19,900)	0 (0)	300 (400)	300 (400)
5	18,700 (24,400)	17,000 (22,200)	1,700 (2,200)	400 (500)	2,100 (2,700)
6	6,000 (7,800)	6,000 (7,800)	0 (0)	200 (200)	200 (200)
7	40,900 (53,500)	37,200 (48,700)	3,700 (4,800)	800 (1,100)	4,500 (5,900)
Total	127,500 (166,800)	118,500 (155,000)	9,000 (11,800)	2,700 (3,500)	11,700 (15,300)

*Figures in parentheses are in cubic yards.

Major excavating equipment normally employed by the operator who will perform the mining on this demonstration project consists of:

1- 9 m^3 (12 cy) wheel loader w/articulated steering

2- 45 Mg (50 ton) off-highway type rear dump trucks

1- 200 kw (270 bhp) crawler tractor w/universal blade

Hourly Labor and Equipment Costs (Applicable to both methods)

Equipment cost rates obtained from the U.S. Army, Corps of Engineers, Equipment Ownership and Operating Expense Schedules were used for estimating costs of equipment requirements and are shown below:

TABLE 9. EQUIPMENT OWNERSHIP AND OPERATING EXPENSE SCHEDULE

Equipment	Ownership and Operating Expense Rate (1-shift)	(2-shift)	Standby Rate
200 kw (270 bhp) Crawler Tractor with Hyd. Universal Blade	$ 37.35/hr	$ 35.08/hr	$ 9.93/hr
45 Mg (50 ton) Off-Highway Rear Dump Truck	$ 52.37/hr	$ 47.75/hr	$16.37/hr
9 m^3 (12 cy) Wheel Loader with Articulated Steering	$103.02/hr	$ 96.40/hr	$22.58/hr

End-haul Equipment costs

1-Wheel Loader @ $103.02/hr = $103.02/hr
2-Trucks @ $ 52.37/hr = $104.74/hr

Total Hourly End-Haul Equipment Costs= $207.76/hr

End-haul Labor costs (1 - 10 hr Shift)

3- Equipment Operators @ $ 7.00/hr + 0.1. = $ 21.00/hr + $ 2.10 0.1./hr
= $ 23.10/hr

Total Hourly Expense for End-Hauling Overburden

= $207.74 + $ 23.10 = $230.84/hr

Bulldozer equipment and labor costs (1 - 10 hr Shift)

1- Crawler Bulldozer	@ $37.85/hr	=	$37.85/hr
1- Operator	@ $ 7.00/hr + 0.7.	=	$ 7.70/hr

Total hourly expense for Bulldozing Overburden = $45.55/hr

Time Requirements

Total end-haul method

I. End-Haul time

Assuming: 127,500 m^3 (166,800 cy) overburden
1- 9 m^3 (12 cy) Wheel loader w/articulated steering
2- 45 Mg (50 ton) off-highway rear dump trucks
Average haul distance = 150 m (500 ft) (one-way)
Overall job efficiency = 75% (45 min/hr)
Material mix = loose after blasting, with large chunks
10 hr shift
No major down time
Average productivity = 260 m^3 (340 cy)/hr

For 10 hour shift, daily productivity = 2600 m^3 (3400 cy)/day

Time to complete: $\frac{127,500\ m^3}{260\ m^3/hr}$ = 490 hours (49 - 10 hr days)

II. Bulldozer Time

Assuming: 2700 m^3 (3,500 cy) Overburden to be bulldozed average distance of 100 feet.
1- 200 Kw (270 bhp) Crawler Tractor with Universal Blade
Base Productivity = 345 m^3 (450 cy)/hr, 30 m (100 ft) level operation
Overall job efficiency = 75% (45 min/hour)
Material mix = predominantly loose, upper level soils
Material mix factor = 1.0
Downhill grading factor = 1.2 for 20% downhill grade
10 hour shift
No major down time

Average productivity = 345 m^3/hr x .75 x 1.0 x 1.2 = 311 m^3/hr

Time to Complete: $\frac{2700\ m^3}{345\ m^3/hr}$ = 8 hours

Partial end-haul method (where applicable)

I. End-Haul time

Assuming: 118,500 m^3 (155,000 cy) overburden to be moved average 150 m (500 ft) (one-way). Same equipment and conditions as

total end-haul method.

Time to Complete: $\frac{118,500\ m^3}{260\ m^3/hr}$ = 456 hr (46 - 10 hour days)

II. Bulldozer Time

Assuming: 11,700 m^3 (15,300 cy) overburden to be moved average 30 m (100 ft)
Same equipment and conditions as partial end-haul, except 0.75 material mix factor.

Average Productivity: 311 m^3/hr x .75 = 233 m^3/hr (305 cy/hr)

Time to Complete: $\frac{11,700\ m^3}{233\ m^3/hr}$ = 50 hr (5 - 10 hour days)

Differential Costs

Comparative expense for total end-haul method

End-Haul Expense	= 490 hours @ $230.84/hr	=	$113,112.00
Bulldozing Expense	= 8 hours @ $ 45.55/hr	=	364.00
Total Expense		=	$113,476.00

Comparative expense for partial end-haul method

End-Haul Expense	= 456 hours @ $230.84/hr	=	$105,263.00
Bulldozing Expense	= 50 hours @ $ 45.55/hr	=	2,278.00
Total Expense		=	$107,541.00

Total Differential Cost to the Operator for Overburden Handling

$113,476.00 - $107,541.00 = $5,935.00

Note that the preceeding calculations are based upon only those components of overburden handling which are considered variable. Examples of non-variable costs include management, labor other than heavy equipment operators, small equipment, special handling of toxic materials, and haul road and silt dam construction and maintenance. Since all end-hauled material must be dumped and then spread and/or graded by bulldozing, expenses for spreading and grading are also considered as non-variable costs.

Since the disturbed area would be less using the total end-haul method, some savings could be realized by the operator in revegetation costs, and permit fees (see Table 10).

Revegetation costs are based upon an estimated unit cost of $865 per hectare ($350.00 per acre). Partial end-haul would disturb approximately 2.9 hectares (7.2 acres) of the project area, and total end-haul would disturb approximately 1.9 hectares (4.6 acres). Permit area fees are based upon $86 per hectare ($35.00 per acre) of disturbed area. Differential cost of revegetation and permit area fees is $1,001.00 saved by the operator due to lower acreage disturbed. This will serve to partially offset the differential cost to the operator for overburden handling. Overall differential cost to the operator will be $5,935.00 less $1,001.00 equals $4,934.00.

TABLE 10. REVEGETATION AND PERMIT AREA COSTS COMPARISON FOR THE DEMONSTRATION AREA

Cost Item	Partial end-haul	Total end-haul	Differential cost saving
Revegetation Cost	$ 2,520.00	$ 1,610.00	$ 910.00
Permit Area Fees	252.00	161.00	91.00
Total	$ 2,772.00	$ 1,771.00	$ 1,001.00

This represents the overall differential cost of mining the project area utilizing total end-haul instead of merely meeting minimum regulatory requirements. Listed below are overburden removal and reclamation costs for several parameters:

TABLE 11. DIFFERENTIAL COSTS OF TOTAL END-HAUL COMPARED TO PARTIAL END-HAUL MINING METHOD

Differential cost per unit volume of overburden handled	Differential cost per unit weight of coal stripped	Differential cost per unit weight of coal stripped and augered
+ $0.04/$m^3$	+ $0.28/Mg	+ $0.17/Mg
+ (0.03/cy)	+ (0.25/ton)	+ (0.15/ton)

Based upon this differential cost analysis, the modified block-cut method of mining, with onsite control of sedimentation is economically feasible for use within the demonstration project area. The demonstration project will document the effectiveness of the modified block-cut (total end-haul) in providing onsite control of sedimentation within the project area and will provide a useful reference for applying the modified block-cut method to larger operations. The documentation of onsite sediment control provided by this demonstration project should provide the basis for future elimination or size reduction of the current requirements for silt dam construction to control sedimentation "off-site". Sedimentation due to the actual construction and maintenance of silt dam fill slopes could be substantially reduced or eliminated, and incidences of damages due to silt dam failure could be reduced or eliminated. Cost savings realized by the operator due to future size reductions or elimination of silt dam construction

should greatly offset the differential cost increase of utilizing the modified block-cut method.

PRELIMINARY DESIGN

Drawings

The location and outline of the project area are shown on Figure 5, Watershed Drainage Area. Subsurface investigation locations, coal contours, and disturbed limits are shown on Figure 6. A typical mining section is included as Figure 7 and shows the relationship of existing ground and proposed regrading.

All overland flow from the project area will continue to outlet into Lower Lick Fork which flows into Bull Creek, which then flows into the Kentucky River. All treatment methods to be employed in this demonstration within the project area will be onsite control of sedimentation through the modified block-cut method of mining. The water quality monitoring station is shown on Figures 5 and 6.

This method of mining will return the ground to its approximate original contour. The relationship of the regrading line to original ground is shown on Figure 7. This figure further shows the portion of the highwall to remain and the road which will stay in place for future access.

All disturbed areas will be revegetated in accordance with the Commonwealth of Kentucky mining regulations and with the recommendations contained herein.

All work to be accomplished as a portion of this demonstration is generally shown on Figures 5, 6, and 7. Preliminary pre-mining plans and cross sections have been developed on a suitable scale for checks of these general plans. Detailed pre-mining plans will be developed as an element of the demonstration project prior to actual mining.

Specifications

The abatement measures used in this demonstration project are intrinsic to the modified block-cut method of mining. Specifications concerning the relevant abatement procedures of the mining operation to be demonstrated are set forth below.

1. All runoff from the project area is channeled into Lower Lick Fork passing through the proposed monitoring station. Minimum peak flow in the creek is zero during dry periods. During mining a two-year peak flow is estimated to be 1.22 m^3/s (43 cfs) and a 100-year peak flow is estimated to be 3.62 m^3/s (128 cfs). Total sediment delivered to the monitoring station during the first three years is estimated to be 30 Mg (33 tons) at an average concentration of 138 mg/l.

Figure 5. Watershed drainage area.

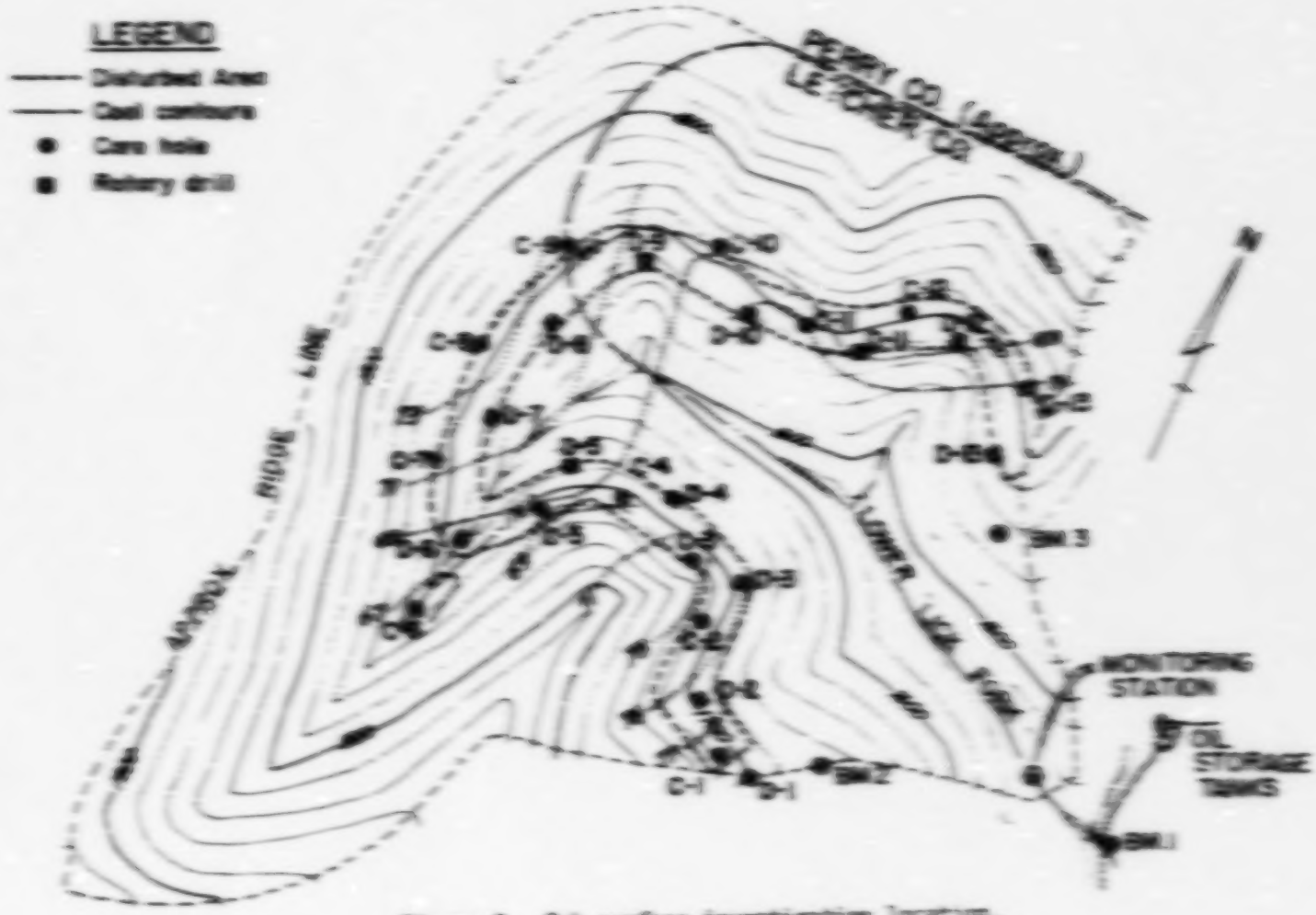


Figure 6. Sub-surface investigation location, coal contours and disturbed limits.

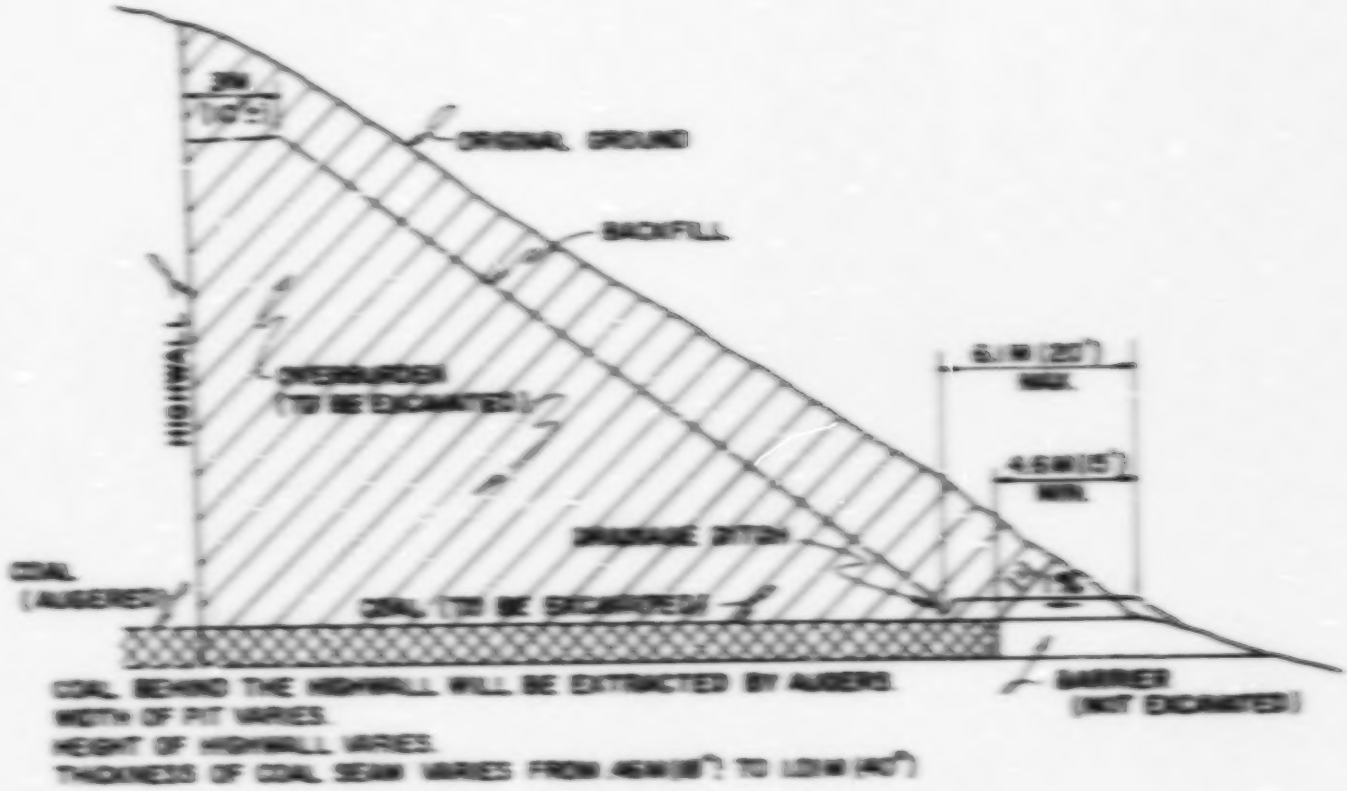


Figure 7. Typical mining section.

8. Construction of treatment facilities is not proposed as an element of this project as the treatment method is a part of the actual mining operation. The monitoring station will have been constructed prior to the actual mining. This station will consist of a parshall flume, thermograph, sampler, flowmeter, and rainfall recorder. The monitoring equipment will be housed in a bullet-proof enclosure. Outline specifications for the equipment and construction of this station are as follows:

Parshall flume--The parshall flume shall be prefabricated of fiberglass. Equipment shall be the same as, or equal to, the flumes as manufactured by Plasti-Fab, Inc., Beaverton, Oregon. A still well shall be included with the flume in accordance with the design details, and the inside surface shall be smooth and free from irregularities. The outside surface will be provided with clips suitable for anchoring to concrete and/or rock.

The flume and still well shall be molded of isophthalic polyester resin and fiberglass to form a minimum wall thickness of 3/16 inch throughout.

Excavation shall be true to lines and grades indicated on the design drawings. Backfill shall be rock and mortar as approved by the Engineer.

Rainfall recorder--The rainfall recorder shall be capable of measuring and recording all forms of precipitation on a rectangular chart. The recording rain gauge shall be Universal Rain Gauge as manufactured by Belfort Instrument Company, Baltimore, Maryland, or approved equivalent.

The gauge shall consist of a collector, a bucket, a dust shield, and a weighing-recording mechanism. Accuracy shall be not less than one-half of one percent with a sensitivity of 0.01 inch of precipitation.

Thermograph--The thermograph shall be constructed in accordance with U.S. Weather Bureau Specification 450.12(j). The temperature-sensitive element shall be a polished chrome-plated, liquid-filled bourdon tube attached by a series of linkages to a recording pen arm. The thermograph shall be the same as or equivalent to the unit manufactured by Belfort Instrument Company, Baltimore, Maryland. It shall be housed in an all metal case with glass panels and mounted on an aluminum base.

Sampler--The sampler shall be capable of operating on a flow proportional basis as controlled by a flowmeter with a contact closure output.

Twenty-four sample bottles shall be capable of storing 500 ml (1.1 pt) of sample, with single or multiple samples. A method

shall be provided to precisely select from 100 to 500 ± 20 ml on each sample. It shall also be capable of pulling a 500 ml sample up to 6.7 m (22.0 ft) through a 9.525 mm (0.375 in.) inside-diameter tube. The unit shall provide alternately for timed samples to be taken every 3.75 minutes or multiples up to 24 hours. The sampler shall be capable of taking up to five samples in one bottle or alternately be able to take four simultaneous samples in four sequential bottles.

The unit shall be operated on a 12 volt battery.

The time to take a 500 ml (1.1 pt) sample at 3 m (10 ft) of head shall be no less than 16 seconds to assure a representative sample including any solids up to 9.525 mm (0.375 in.) in size. No liquid shall pass through any pump. A positive purge cycle shall be initiated before the sample is taken to clear the inlet hose. A second positive purge cycle shall assure that all surplus liquid is expelled from the tubing on the completion of a cycle, providing for a fresh sample on the next cycle.

The sampler shall be the same or equivalent to the unit manufactured by Manning Environmental Corporation, Santa Cruz, California.

Flowmeter -The flowmeter shall use a sensor which is not required to float in or otherwise submerge below the surface of the liquid, or otherwise interfere with floating debris. The sensor shall be unaffected by chemicals, abnormal pH levels, or high temperature.

The flowmeter shall provide flow rate data on a dial indication. A six-digit counter shall provide a continuous totalized display of total flow. Multiplying factors shall be supplied as a function of the type of primary device. A switchable channel selector shall provide three channel configuration options - circular pipes, Parshall flumes and V-notch weirs.

The instrument shall record flows over a 0-305 mm (0-12 in.) to 0-1220 mm (0-48 in.) range of flow and provide a continuous dial indication of the liquid level.

All components shall be made of corrosion-resistant material and shall be able to withstand surcharges of the measured liquid.

The flowmeter shall be complete and provided with the following: a module containing a flow recording dial (and chart) and totalizing counter; a sensor 38 mm (15 in.) long connected to the module with an insulating cable; a 12 volt rechargeable battery sufficient to maintain recordings for 8 days; carrying case; one year supply of charts and extra pen, instruction manual and set of tables for various primary devices. The flowmeter shall have a contact closure output which shall control an automatic sampler on a flow-proportional basis.

The flowmeter shall be the same as, or equivalent to, the unit manufactured by Manning Environmental Corporation, Santa Cruz, California.

Miscellaneous--The enclosure shall be constructed of one-fourth in. thick steel in accordance with the design details.

Supports shall be three in. galvanized pipe anchored into solid rock and encased in concrete.

3. Soil samples were taken from the overburden at five locations in the project area. The sampling locations were widely spaced along the coal seam. Three separate subsamples were taken at each of the five locations at 0.3 m (1.0 ft) intervals to a depth of 1 m (3 ft) below the surface. Chemical analyses of the soil samples were performed by the University of Kentucky, College of Agriculture.

   On the basis of the chemical analyses, the University recommended fertilizer supplements for revegetation of the regraded mine spoil. Fertilizer recommendations for each soil sample are shown in Table 12 on the following page.

4. A total of 127,500 m^3 (166,800 cy) of overburden will be removed by the haul-back method and regraded prior to revegetation. Two (2) percent of the overburden is topsoil as discussed in Item 3 above. Topsoil will be temporarily stored on the barrier before it is placed back on the regraded overburden.

5. The methods and types of revegetation may well be the key to the success of this demonstration. The operator has utilized a seed mixture acceptable to regulations in a nearby area which is presently being seeded. This mixture has been successful in this operation and is recommended in the demonstration due to similar types of conditions. The mixture and application rates are shown in Tables 12 and 13.

   The seeding sequence during the months of August and September will be controlled by rainfall and temperature during these months when the actual mining is to be conducted. Mulch will be applied in accordance with state regulations.

   Seedlings will be spotted at a rate of 1980 per hectare (800 per acre), and will be selected from types which are most common to the general area.

6. Depending upon weather conditions, seeding will follow grading within 15 days and be completed for the entire project within 60 days of stripping the overburden. Soil preparation will not be necessary since seeding will take place before the surface crust forms. Fertilizer will be added as set forth in Table 12. The

TABLE 12. RECOMMENDED AMOUNT OF FERTILIZER FOR EACH SOIL SAMPLE*

		Type of Fertilizer							
		N		P_2O_5		K_2O		Lime	
Units		kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac	Mg/ha	Tons/ac
Soil Sample†									
2	a	67	60	157	140	34	30	4.5	2.0
	b	67	60	157	140	67	60	4.5	2.0
	c	67	60	157	140	67	60	4.5	2.0
4	a	67	60	157	140	34	30	6.7	3.0
	b	67	60	157	140	34	30	6.7	3.0
	c	67	60	157	140	34	30	4.5	2.0
8	a	67	60	157	140	0	0	4.5	2.0
	b	67	60	157	140	0	0	4.5	2.0
	c	67	60	157	140	0	0	4.5	2.0
11	a	67	60	157	140	34	30	6.7	3.0
	b	67	60	157	140	34	30	4.5	2.0
	c	67	60	157	140	34	30	4.5	2.0
13	a	67	60	157	140	67	60	4.5	2.0
	b	67	60	157	140	67	30	4.5	2.0
	c	67	60	157	140	67	60	4.5	2.0

*Average recommendations for the entire site:

N-- 67 kg/ha (60 lb/ac)
P_2O_5--157 kg/ha (140 lb/ac)
K_2O-- 34 kg/ha (30 lb/ac)
Lime-- 4.5 Mg/ha (2.0 Tons/ac)

†Sample depth: a = 0.0-0.3 meters (0.0-1.0 feet)
b = 0.3-0.6 meters (1.0-2.0 feet)
c = 0.6-0.9 meters (2.0-3.0 feet)

pH factor ranges from 5.1 to 6.5 and lime will be added to the soil to raise the pH factor as specified in the above table.

7. Seeds will be applied by a hydroseeder. Trees will be planted by hand.

TABLE 13. RECOMMENDED APPLICATION RATES FOR SEED MIXTURE

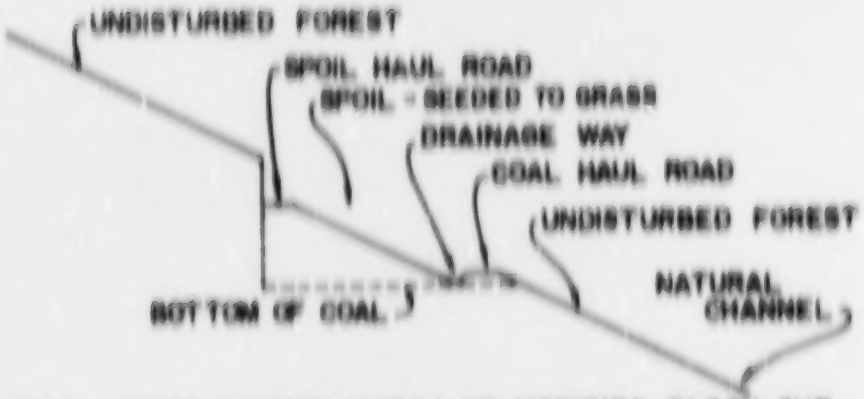
Seed	Rate	
	lb/acre	kg/hectares
Kentucky 31 fescue	20.0	22.4
Perennial rye grass	7.0	7.8
Sweet clover	5.0	5.6
Red clover	2.0	2.2
Alsike clover	1.0	1.1
Orchard grass	1.5	1.7
Red top	2.5	2.8
Weeping love grass	2.5	2.8
Serices lespedeza	3.0	3.4

Expected Mine Water Quality and Quantity

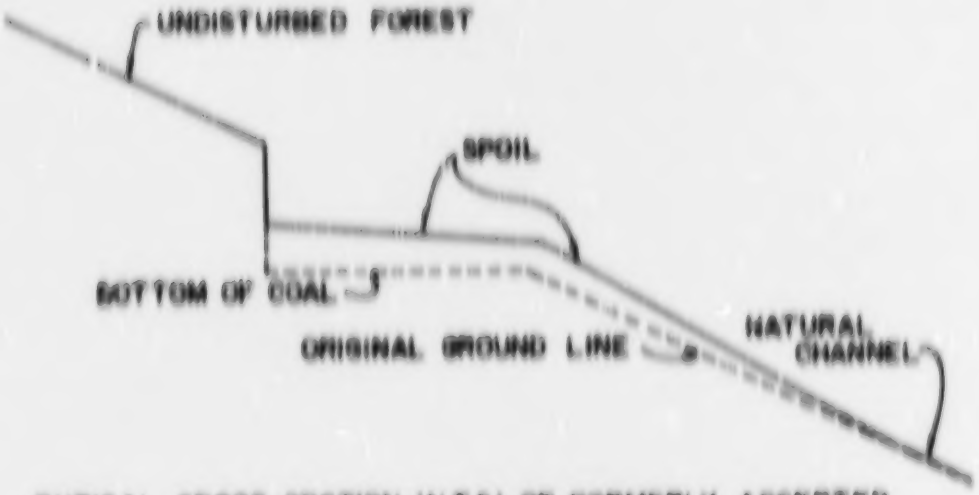
Procedures for quantitatively estimating erosion and sediment production from strip-mined watersheds have not been developed. In the calculations used in arriving at the estimates shown below, it was necessary to modify procedures used in estimating soil loss from agricultural areas and sediment transport relationships for open channels. The procedures have been verified in many cases for the conditions under which they were developed, however, their extrapolation to the present application is somewhat speculative. In spite of these drawbacks the procedure used for estimating sediment production should yield valid comparisons between the block-cut method of mining as proposed for this project and the conventionally used methods of mining. Data collected during the project will aid in verifying the sediment production calculations.

In the calculations that follow, the project area is assumed to have a final regrade shape as shown schematically in Figure 8 when the block-cut and conventional methods of mining are used. For the purpose of these calculations, these cross-sections are assumed to run continuously around the demonstration site for a total length of approximately 730 meters (2400 ft). In the block-cut method, a culvert is assumed to exist under the coal haul road at 244-meter (800 ft) intervals to provide a means for water to leave the drainage way and enter the natural channel draining the project watershed. These culverts are located in natural draws in the existing topography.

Before estimates of sediment production can be made, it is necessary to estimate runoff hydrographs and rain storms for the return periods to be considered. In this work calculations were carried out for a 2-year and 100-year frequency rain storm. This enables a comparison on the basis of a common event (the 2-year storm) and a rare event (the 100-year storm). The



TYPICAL CROSS-SECTION (N.T.S.) OF MODIFIED BLOCK-CUT METHOD OF MINING (AFTER MINING)



TYPICAL CROSS-SECTION (N.T.S) OF FORMERLY ACCEPTED CONVENTIONAL METHOD OF MINING (AFTER MINING)

Figure 8. Cross-sections of modified block-cut and conventional methods of mining.

The rainstorm for these two frequencies was developed in five-minute increments from information contained in the Kentucky Department of Highways "Manual of Instruction for Drainage Design" (1971).[6]

The National equation (Haan and Barfield, 1972)[7] was used to estimate peak runoff rates. The time of concentration for the entire demonstration site was estimated at 5 minutes. The time of concentration of flow into the drainageway of the modified block-cut mining area would be less than 5 minutes; however, since the shortest duration for which reasonably accurate rainfall information can be developed is 5 minutes, it was necessary to consider the time of concentration for this flow as 5 minutes as well.

The 5-minute, 2-year rainfall intensity for the project site is 115.6 mm (4.55 in.) per hour. The 5-minute, 100-year rainfall intensity is 224.8 mm (8.85 in.) per hour. The rational "C" for the forest area was taken as 0.20 and for the spoil as 0.70.

Using these factors it was estimated that the peak rate of inflow into the drainageway of the block-cut mined area would be 0.030 m^3/s (1.09 cfs) for 30 meters (100 ft) of length for the 2-year event and 0.059 m^3/s (2.13 cfs) for 30 meters (100 ft) of length for the 100-year event. Considering a 244-meter (800 ft) drainage way, the peak discharge into the road culverts are thus estimated at about 0.247 m^3/s (8.72 cfs) for the 2-year event and 0.483 m^3/s (17.04 cfs) for the 100-year event.

The runoff volume for the maximum 2-year, 5-minute rainfall increment was estimated as 1.8 mm (0.07 in.) using the procedure outlined by the Soil Conservation Service and discussed by Haan and Barfield (1972).[7]

Thus three properties of a 2-year runoff hydrograph have been estimated:

1. the peak flow rate of 0.247 m^3/s (8.72 cfs)
2. the time to peak of 5 minutes
3. the volume of runoff due to the 5-minute rainfall of 1.8 mm (0.07 in.)

These three factors are sufficient to define the shape of a unit hydrograph if the procedure proposed by Haan (1972)[7] is used. Once the unit hydrograph is determined, it can be used to generate a runoff hydrograph corresponding to the 2-year rainstorm.

Since unit hydrographs must be used in conjunction with rainfall excess and not rainfall, it is necessary to determine rainfall excess from the 2-year rainstorm. Rainfall excess is defined as that portion of the rainfall that is available for surface runoff.

Again the rainfall excess was estimated using the Soil Conservation Service procedure. The rainfall excess for each 5 minutes of the 2-year rainstorm was determined. This rainfall excess was then combined with the unit hydrograph previously estimated to obtain the estimated runoff hydrograph into any one of the culverts used to remove water from the drainage-

way along the coal haul road. The results of these calculations are shown in Figure 9.

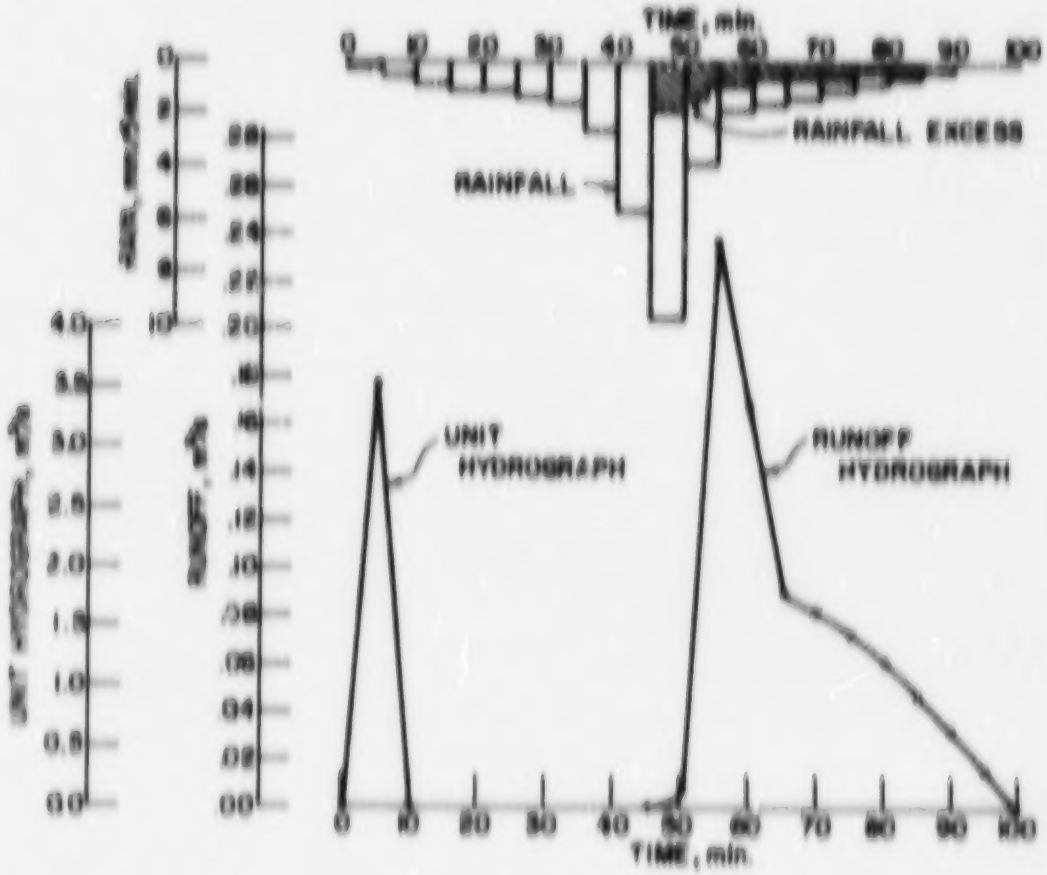


Figure 9. Estimated 2-year runoff event for drainage way along coal haul road

The procedures outlined above were repeated for the entire demonstration watershed assuming three conditions:

1. natural forest
2. block-cut mining
3. conventional mining

The results of these calculations are shown in the form of runoff hydrographs in figures 10 and 11. From these figures it can be seen that the block-cut mining will initially increase the 2-year peak runoff by 30 percent (1.218 m^3/s (43 cfs) versus 0.935 m^3/s (33 cfs)) while the conventional method of

mining will increase the same event by 100 percent [1.84] m^3/s (65 cfs) versus 0.935 m^3/s (33 cfs)].

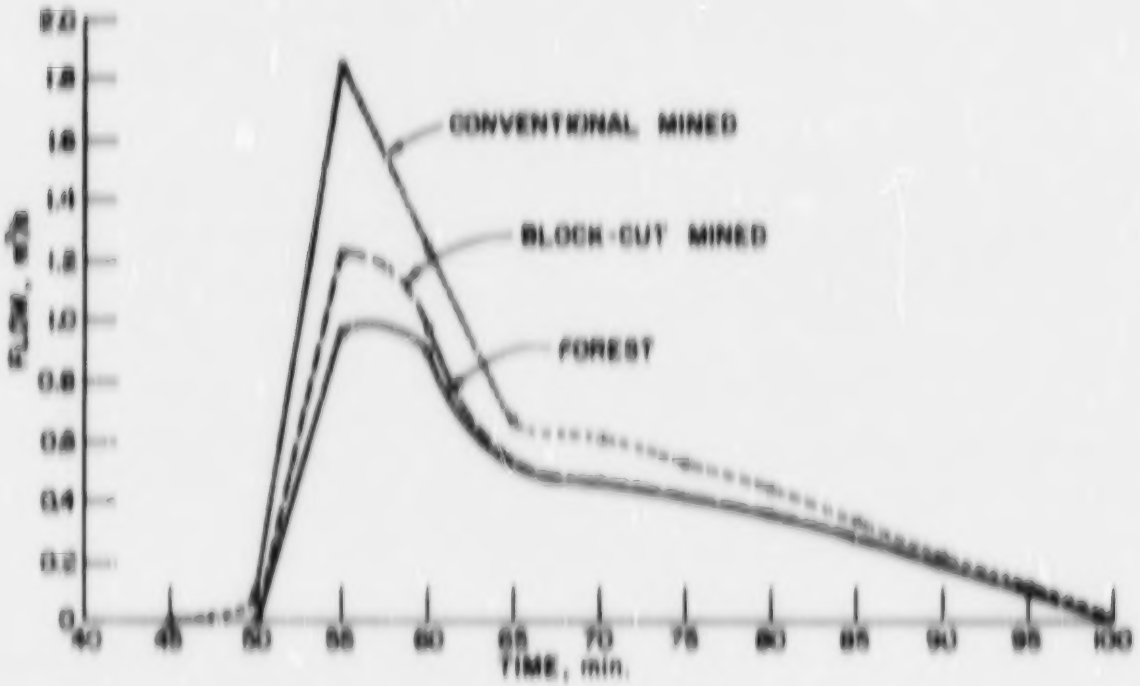


Figure 10. Two-year runoff hydrograph from demonstration watershed.

The 100-year event will be increased 22 percent [from 2.973 m^3/s (105 cfs) to 3.625 m^3/s (128 cfs)] on the block-cut mined area whereas it would be increased by 61 percent [from 2.973 m^3/s (105 cfs) to 4.786 m^3/s (169 cfs)] under conventional mining practices. The fact that the flow rates from the block-cut mined area will be considerably less than from the same area under conventional mining in itself indicates a large decrease in the sediment carrying capacity of the stream draining the watershed.

The estimation of the sediment that would be produced from strip mining on the demonstration site was done by (a) using the Universal Soil Loss Equation (USLE) to estimate gross erosion, (b) using sediment transport theory to estimate the sediment carry capacity of the drainageway along the coal haul road, and by (c) estimating the fraction of sediment trapped in moving into the road culverts and along the main stream of the watershed.

The channel or drainageway along the coal haul road (Figure 8) intercepts all runoff and sediment produced from the mining activity when the block cut method of mining is used. This channel will be about 0.3 m (1 ft) deep, 1.2 m (4 ft) wide at the top and triangular in shape. The channel will run about 4.5 miles around the mountain along the coal haul

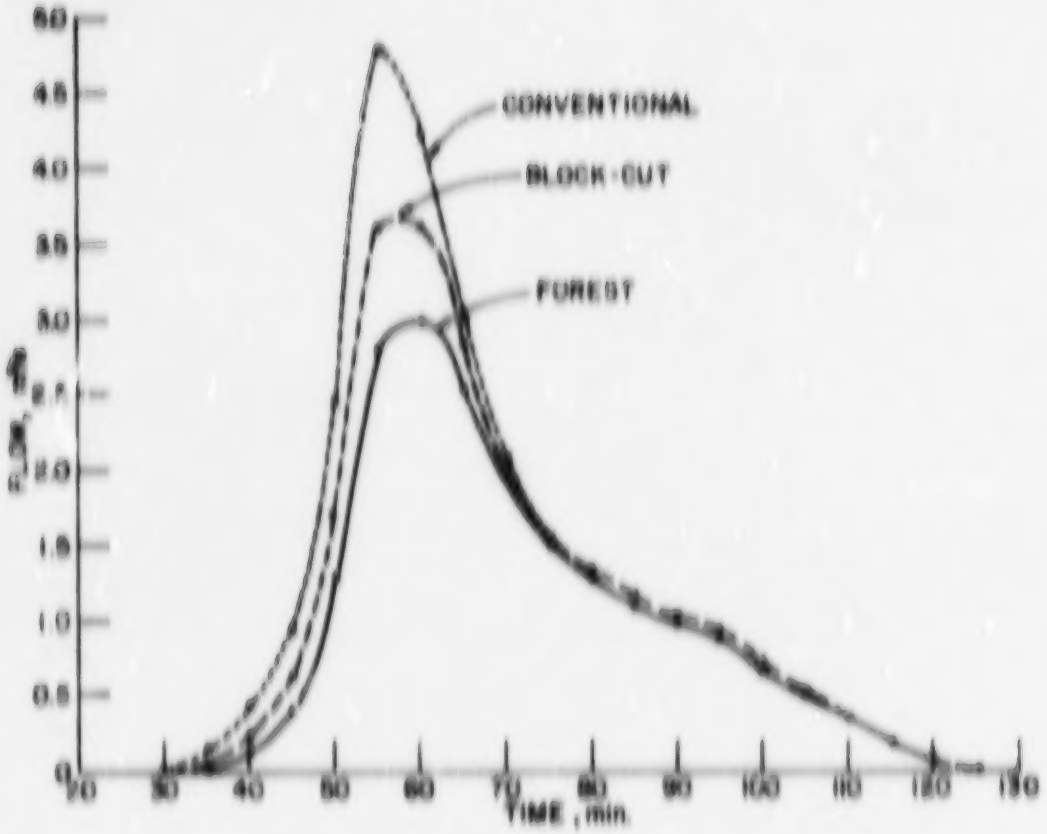


Figure 11. One-hundred-year runoff hydrograph from demonstration watershed

road. Its water carrying capacity is about 0.227 m^3/s (8 cfs) or equal to the expected peak flow from a 2-year rainstorm.

Based on uniform flow in the channel and equilibrium conditions, Graf (1971)[8] presents methods for estimating the capacity of a channel to transport bed material load. Since the material that composes the spoil will be essentially the same as the material in the channel bed, these procedures in Graf were used to estimate the sediment carrying capacity of the channel as a function of the water flow rate in the channel.

The actual calculations involved are too detailed to include in this report. Basically the bed material load is broken into several size fractions and the sediment transport capacity of the channel for each size fraction determined. Then based on the fraction of the bed material load in each size fraction, the total transport capacity of the channel can be estimated. The particle size distribution of the bed material load is shown in Figure 12.

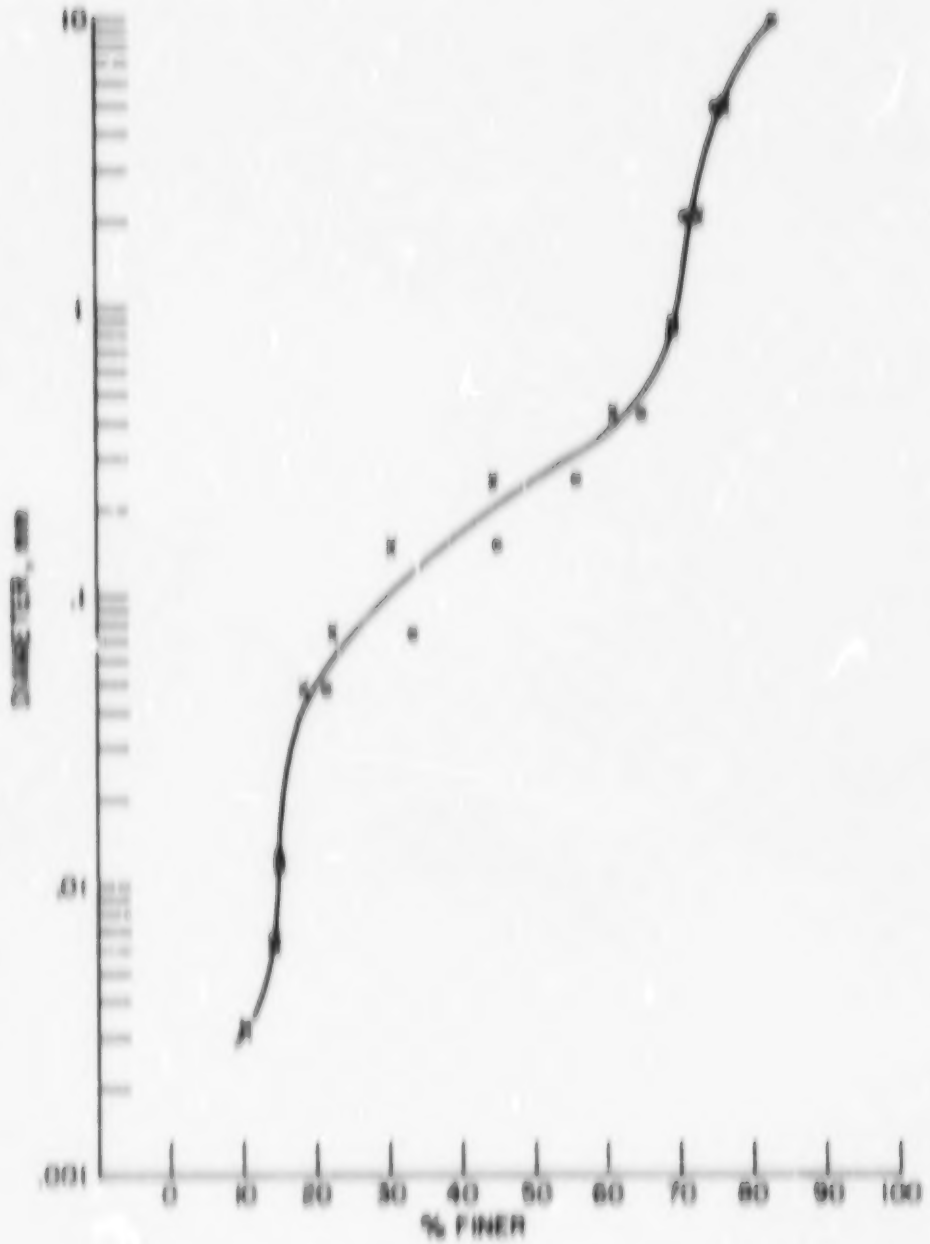


Figure 12. Particle size distribution of material to be placed on top of spoil.

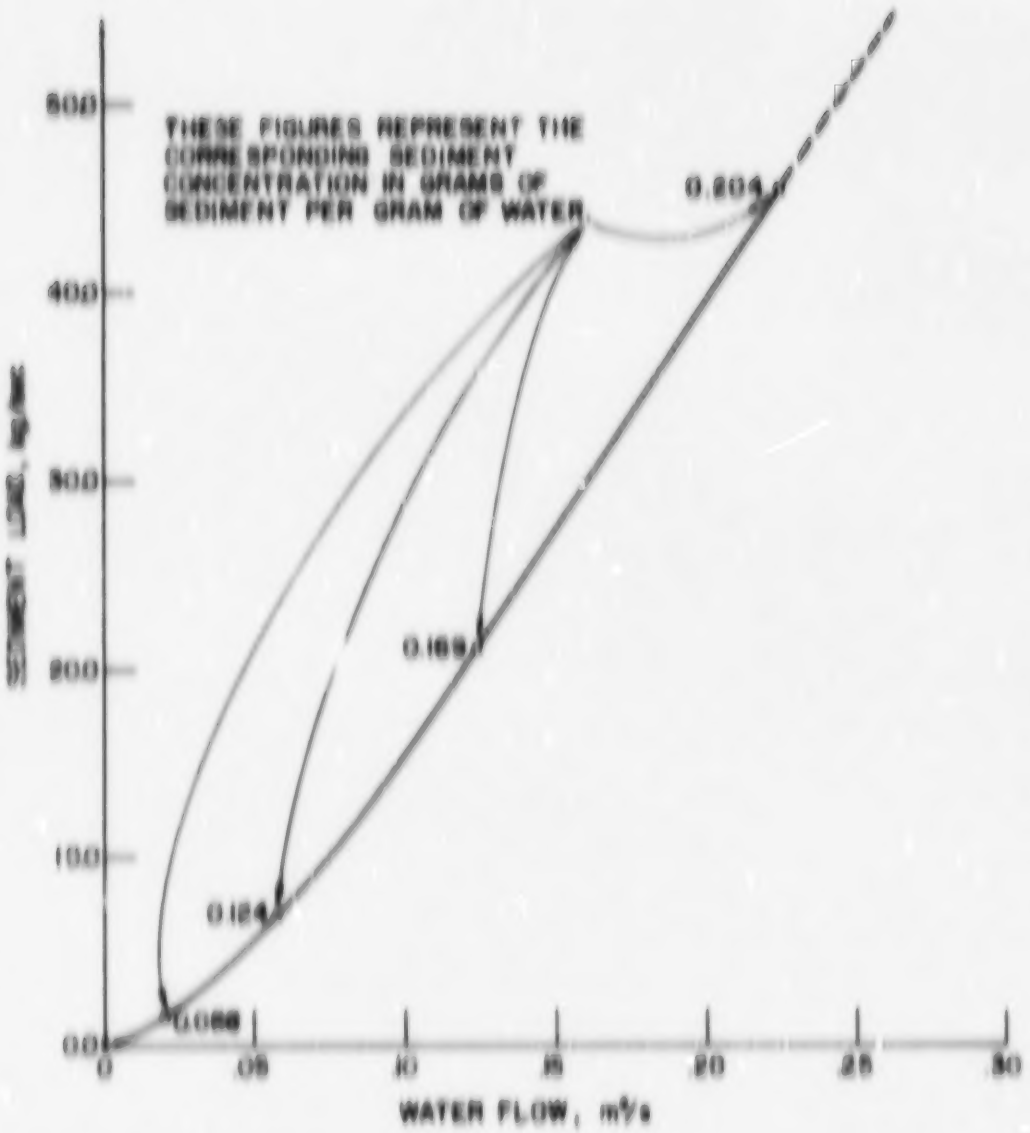


Figure 13. Sediment rating curve for drainage channel along coal haul road.

Figure 13 is the resulting sediment rating curve for the drainage channel as a function of water flow rate in the channel. As can be seen this channel will carry very high concentrations of sediment. This is because of the relatively steep channel slope (1.3 percent), small and easily eroded particles and high channel velocities (about 1.2 m (4 ft) per second at bankfull discharge). Again it must be kept in mind that assumptions have gone into determining the sediment rating curve. Some corrections will have to be applied to the curve to account for some of the assumptions that are violated.

If the sediment rating curve (Figure 13) is applied to the 2-year runoff hydrograph (Figure 9) for the 244 m (800 ft) channel, a sediment graph can be determined as shown in Figure 14. If the area under the sediment graph is

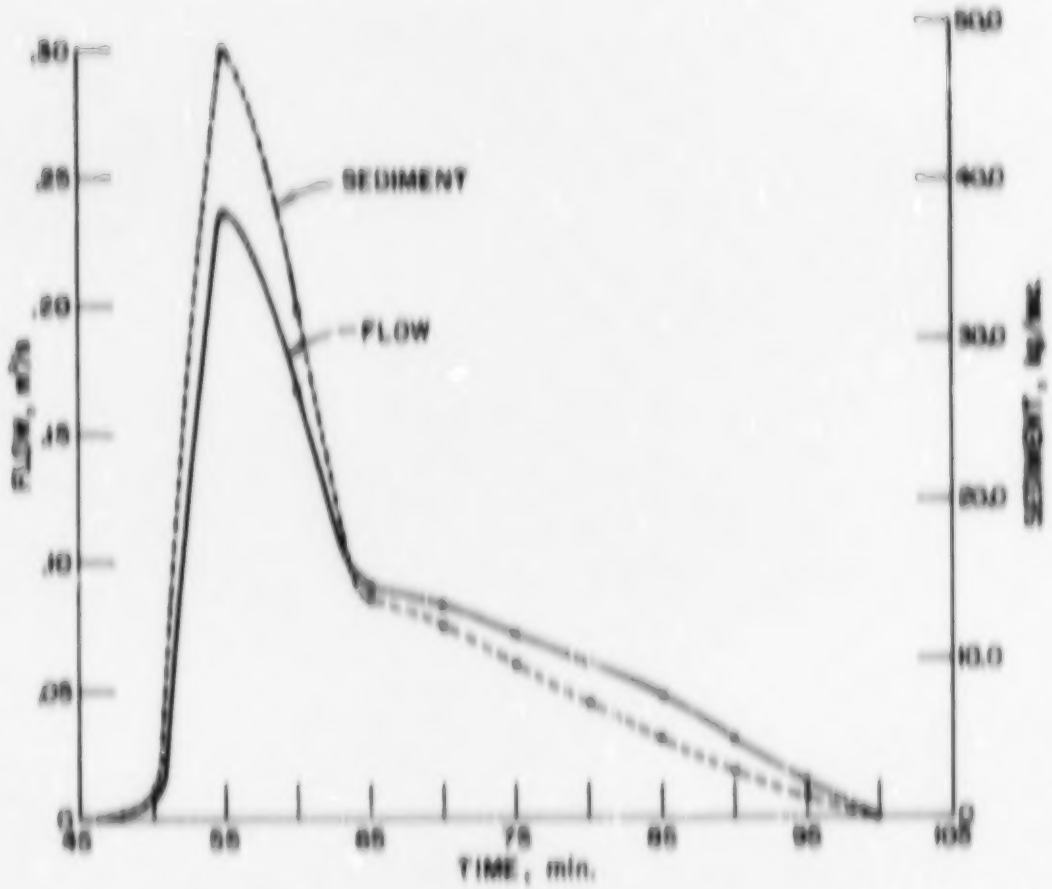


Figure 14. Two-year storm flow at end of 800' channel.

measured, the maximum possible amount of sediment that can enter the culverts under the coal haul roads can be estimated. The area under the sediment graph represents 40 Mg (44 tons) of sediment.

This estimated 40 Mg (44 tons) is now reduced by a factor of 4 to account for the fact that:

1. The channel does not carry the indicated water for its entire 244 m (800 ft) but only at the very downstream end of the channel;

2. Rock filters and small settling areas will be used at the entrance to the culverts; and

3. A large part of the material is in the sand range.

Thus, the estimated discharge from each culvert is 10 Mg (11 tons) of sediment for a 2-year rainstorm. Since each culvert handles 244 meters (800 ft) and there is a total of 730 meters (2400 ft) in the basin, 3 culverts are required for a total sediment production from the culverts of 30 Mg (33 tons) of sediment.

Part of the sediment flowing from the culverts will be trapped before reaching the watershed outlet at the project monitoring station. It is assumed here that half of the sediment from the culverts will be trapped. This means a 2-year storm might produce 15.0 Mg (16.5 tons) of sediment at the monitoring station.

The above calculations of sediment delivery are based mainly on the sediment transport capacity of the drainage channels along the coal haul road. If we estimate the total sediment delivered to this channel from the spoil material via the USLE, and estimate of the delivery ratio or that fraction of the eroded sediment that actually leaves the watershed can be made.

The USLE is:

A = RKLSCP

Where A is the soil loss in tons/acre

R is a rainfall factor based on rainfall energy and intensity

K is an erodibility factor

L is a slope steepness factor

C is a cover factor, and

P is a practice factor.

The estimates for these quantities based on procedures outlined in Barfield and Haan (1972)[9] and USDA Forest Service Handbook 3509.21 NA[10] are K = 0.3, LS = 20, C = 0.8, and P = 1.0.

The rainfall factor R was calculated from the 2-year storm to be 26. Combining these factors along with the area of disturbed spoil, a sediment production from the 2-year storm of 500 Mg (550 tons) is estimated.

The watershed delivery ratio is thus estimated by dividing the estimated amount of sediment delivered to the monitoring station by the estimated sediment production. Thus the delivery ratio is:

$$DR = \frac{\text{sediment delivered}}{\text{sediment produced}}$$

$$= \frac{15.0 \text{ Mg}}{500 \text{ Mg}} = 0.03$$

This delivery ratio of 0.03 will now be used along with the USLE to estimate the sediment lost from the demonstration project over a 3-year period beginning with the initiation of mining on August 1, 1976.

From this point, the following conditions are assumed:

1. The blasting operation requires 30 m (100 ft);
2. Overburden removal requires 30 m (100 ft);
3. Coal removal requires 30 m (100 ft);
4. Augering of coal requires 30 m (100 ft);
5. Spoil placement requires 150 m (500 ft);
6. Mine at rate of 20 m (70 ft) per day for 20 days per month;
7. Exposed areas are mulched at rate of 450 kg of wood/fiber mulch per hectare (400 lb/acre); and
8. Seeding is done the first of each month, September through December.

Using these assumptions a month-by-month computation of sediment production based on the USLE was made for the period August 1, 1976 through July 31, 1977. The results of these calculations are shown in Table 14. The actual sediment reaching the monitoring station is determined by multiplying the sediment produced by the delivery ratio of 0.03. This information is also shown in Table 14. From Table 15 it can be seen that the estimated first year sediment delivered will be 25.0 Mg (27.6 tons) at the monitoring station.

Watersheds in this part of Kentucky generally produce 460 mm (18 in.) of runoff per year. This amount of runoff along with 25.0 Mg (27.6 tons) of sediment represents an average sediment concentration of about 360 mg/liter (20 grains/gal).

For the second year the same procedure was used and an estimated average sediment concentration of 20 mg/liter (3 grains/gal) was determined. Similarly for the third year the estimated average sediment concentration is 10 mg/liter (1 grain/gal).

TABLE 14. ESTIMATED SEDIMENT PRODUCTION AND SEDIMENT DELIVERY TO MONITORING STATION BY MONTHS FOR THE FIRST YEAR.

Month	Sediment produced		Sediment delivered	
	Megagrams	Tons	Megagrams	Tons
August	266	294	8.0	8.8
September	261	288	7.8	8.6
October	93	102	2.8	3.1
November	43	47	1.3	1.4
December	19	21	0.6	0.6
January, February and March (total)	62	68	1.8	2.0
April, May, June, and July (total)	98	108	2.8	3.1
	842	928	25.0	27.6

TABLE 15. SEDIMENT DELIVERED TO MONITORING STATION

Item	Mg	Tons	Disturbed Mg/ha	Disturbed tons/acre	Disturbed m^3/ha	Disturbed Acre-ft/acre disturbed	mg/liter
Project Site							
Year 1	25.0	27.6	14.10	6.30	8.83	0.0029	350
Year 2	3.5	3.8	1.93	0.86	1.22	0.00040	48
Year 3	1.2	1.3	0.67	0.30	0.43	0.00014	16
3 yr. period	29.7	32.7	16.71	7.46	10.48	0.00344	
Avg. for 3 years	9.9	10.9	5.58	2.49	3.50	0.00115	138

These sediment production figures can be stated in various terms. Table 15 summarizes them in terms of total sediment production, sediment production per unit of disturbed area, sediment volume per unit of disturbed area, and average sediment concentration in the stream at the monitoring site in mg/liter.

The sediment production during the year of active mining (Year 1) will be relatively high but is projected to fall within the current Kentucky Division of Reclamation regulations. These regulations state that the suspended sediment cannot exceed 350 mg/l (19 grains/gal) except during precipitation events when it cannot exceed 2200 mg/l (129 grains/gal). Thus the average suspended sediment permissible is near or somewhat greater than is expected from the project site. The average figure of 350 mg/l (20 grains/gal) shown in Table 15 for year 1 is made up of low flows when the concentration will be considerably less than 350 mg/l (20 grains/gal)

and high flows during storm runoff periods when the concentrations will be somewhat higher than 350 mg/l (20 grains/gal). This is in keeping with the regulations mentioned above. Obviously sediment production during the second and third years will be well below the required levels.

The effectiveness of the block-cut method of mining in controlling sediment can be seen by comparing the figures in Table 15 with results reported from other studies on conventional mine sites. For example Collier, et al (1970)[11] reported that 94 Mg/hectare (42 tons/acre) of sediment were produced in the disturbed area over a three year period on a conventionally mined area in Eastern Kentucky. This compares with an estimated production of only 16.71 Mg/hectare (7.46 tons/acre) of disturbed area using the block-cut method. This reduction plus the fact that only about one-third as much area is disturbed indicates the total sediment production is reduced by a factor of nearly 17 or only about 6% as much sediment is produced with the block-cut method as compared to the conventional method.

Hines (1975)[12] and Davis and Hines (1973)[13] state that approximately 610 m^3/hectare (0.20 acre-feet/acre) of sediment is produced from the disturbed area on strip mines in Eastern Kentucky over a 3-year period. It is expected that only a small fraction of this amount, 9 m^3/hectare (0.003 acre-feet/acre) will be produced from the demonstration site.

Curtis (1971,[4] 1972,[14] 1974[15]) reported sediment concentrations of up to 30,000 mg/l (1750 grains/gal) from conventionally strip-mined areas. Although projections have not been made for the maximum or peak sediment concentrations, it is expected that they will not exceed the 7200 mg/l (420 grains/gal) required by Kentucky regulations.

Thus it is apparent that the block-cut method of mining will greatly reduce sediment production when compared to conventional stripping methods. It is expected that sediment basins will not be required to meet current Kentucky regulations when the modified block-cut method of mining is used.

Design and Construction Schedule

The overall operation schedule for the project from initial water quality sampling through preparation of the final report is set forth in Figure 15 and in the discussion of implementation and operating plans.

Detailed plans and specifications for the monitoring station will start by the first of September 1975 and construction is expected to take place in October 1975. Detailed mining plans will be started in December 1975 and completed by March 1976. The plans will be field reviewed and staked out by the end of March 1976.

The mining layout and start-up procedure will be completed in April 1976 and mining will start in August and extend through September 1976.

In the post-mining period, the "As Mined" plans will be prepared in the fourth quarter of 1976. Water quality sampling and testing will extend until the end of August 1977 or 1 year after completion of mining. After termina-

tion of the water sampling the monitoring station will be removed and the final report prepared. It is expected that the final report will be completed by the end of 1977. The entire project from the initiation of water sampling to completion of the final report will encompass a span of 3 years.

Program Surveillance Measures

It is anticipated that this demonstration will provide detailed information regarding the water pollution abatement capabilities of the block-cut method of mining. Initial calculations indicate the sediment yield to be substantially less than that associated with methods of mining utilized in the past. The calculations as presented herein compare the anticipated yield with the outslope spoil disposal methods previously utilized. The recently approved Commonwealth of Kentucky mining regulations will obviously control the amount of spoil which can be placed on the outslope. However, the method of mining to be demonstrated will apparently meet all the new requirements and will minimize the disturbed area by virtually eliminating material on the outslope.

A permanent monitoring station will be constructed at the downstream limit of the project area. This station will provide up to six months of samples prior to the actual mining operation. The station will consist of a Parshall flume with stilling well, a flowmeter with recorder, a twenty-four bottle automatic flow proportion sampler, a thermograph, and a rainfall recorder. The station will also be utilized during the mining operation, and will record data for twelve months after the completion of mining to relate the effects of the revegetation effort. Outline specifications for the materials and equipment to be utilized in this station are presented elsewhere in this study.

Weekly samples will be collected prior to mining, during mining, and after mining. These samples will be tested for pH, specific conductance, turbidity, hardness, alkalinity, acidity, iron, calcium, magnesium, manganese, suspended solids, settleable solids and sulfate. Additionally, pollutographs will be developed utilizing up to twenty-four discrete samples for significant events. One pollutograph per month during a rainfall event prior to mining, a pollutograph for each significant rainfall event during mining, and one per month after mining will be developed. These pollutographs will reflect pH, suspended solids, flow, iron, manganese, and calcium. In this manner the relationship of pollutants during a rainfall event may be established for an area virtually free of man made pollutants, the effects during mining may be developed, and the effects of revegetation may be documented.

Surveillance measures will also include a minimum of weekly checks of the monitoring station and repairs to the equipment as required. A registered professional engineer and a resident inspector will be assigned to the project full time during the actual mining which is anticipated to last two to three months. These personnel will evaluate the operation relative to the accepted pre-mining plans for conformance with methods and disturbed limits, will record time for all other personnel and equipment, will estimate amount of overburden and mineral removed on a daily basis, and will record all significant events including revegetation and reclamation efforts.

These surveillance measures will provide all data required to evaluate the effectiveness of the control of the sedimentation problem utilizing the block-cut method of mining.

Program Emergency Procedures

All measures for correcting emergencies which may occur as a result of the actual mining operation will be provided by the operator. The monitoring station has been designed to measure flows up to 25-year storms. A 100-year storm could provide problems, but is not considered to be critical. Excess flow should flow over the flume, but could cause movement. The corrective measures in that event would be provided by Watkins and Associates personnel.

A trained inspector will visit the monitoring station weekly to set clocks, exchange batteries, pick up charts, pick up samples, and provide routine maintenance. His visits will preferably be during or immediately after a rainfall event. Additionally, the consultant intends to contract with a reputable local person to check the station daily for vandalism. Although the equipment is to be housed in a bullet proof container, vandalism could occur due to the remote location. The local person will be instructed to immediately notify the consultant in the event that vandalism occurs. The consultant will immediately proceed to provide the necessary repairs.

CAPITAL AND OPERATING COSTS

Site Acquisition Costs

There will be no costs to this demonstration project for legal fees, purchase costs, or lease costs. Certicoals, Incorporated has obtained surface and mineral rights within the project area, and a letter from this organization granting access rights and expressing a willingness to cooperate is included in the study files.

Construction Costs

The only equipment costs directly charged to this project will be for the permanent monitoring station. These funds have previously been approved from a surplus remaining in the feasibility study budget. This surplus was available due to a change in the size of the project area, and the station will thereby be in place prior to the occurrence of winter weather. This will enable the project team to obtain approximately 6 months of water quality data utilizing the monitoring station prior to actual mining. Engineering fees associated with the construction of the monitoring station have been allocated as a portion of the feasibility study. The basis of the estimates for design and construction of the monitoring station included equipment prices for suppliers plus rates for construction, labor, materials and equipment.

Operating Procedures

The administration of the demonstration project will be the task of the

Department for Natural Resources and Environmental Protection of the Commonwealth of Kentucky. The actual mining will be accomplished by Carlcoals, Incorporated. Inspection of mining activities, and the sampling and testing of water quality will be the responsibility of Watkins and Associates, Inc. and Dr. C.T. Haan. Materials and supplies presently anticipated for use on this project include replacement batteries, charts, battery chargers and miscellaneous apparatus for the continuous operation of the monitoring station. These replacement parts will be directly charged to the project at cost. All equipment and parts will become the property of the Environmental Protection Agency at the completion of post-mining sampling and testing.

All chemicals and apparatus required for water quality testing will be provided by Watkins and Associates, Inc. Maintenance of the monitoring station will be provided by Watkins personnel.

Personnel Requirements

Overall administration of the demonstration project will be provided by personnel of the Department for Natural Resources and Environmental Protection, Office of Planning and Research. This office has administered several similar contracts, and the personnel are experienced in this type of effort.

The administration of the portion of the project to be conducted by Watkins and Associates, Inc. will be the responsibility of principals of the firm. The duties will be shared by the two individuals who were designated as principal investigators during the feasibility study. The job description must include assignment of other personnel, maintaining progress schedule, report writing, and assuring the quality of all work.

The individuals must be registered professional engineers with a minimum of 15 years experience. Expected compensation range of these individuals is $25 per hour.

Detailed preparation of mining plans will be accomplished by principal engineers of various specialties. Structural, electrical, environmental, civil, and hydrologic engineers from the staff of Watkins and Associates, Inc. will be utilized as their disciplines are required. A principal resident engineer experienced in construction inspection will be assigned to the project full time during mining. All principal engineers must be registered in their specialties and must have a minimum of five years experience. A compensation range of $15 to $20 per hour is expected for their services.

A nationally known sedimentation and erosion control specialist will assist the Watkins staff on this project. He holds a Ph.D. in Agricultural Engineering and will evaluate the monitoring results particularly as related to actual sediment yield versus anticipated yield. Expected compensation for his services will be at a rate of $25 per hour.

Field surveys will be conducted by a survey party including a registered land surveyor. This work will include detailed layout of mining limits in accordance with the pre-mining plan. As-mined plans will also be prepared. Rates for the survey party are anticipated to range from $25 to $28 per hour.

Technical support personnel will be employees of Watkins and Associates, Inc. These specialists will include a chemist for water quality testing, designers, draftsmen, secretaries, and a resident inspector for work during mining. The anticipated hourly rates for these personnel would range from $4 to $7 plus overhead.

Operating Costs

Estimated costs of operation and maintenance on this project are as follows:

Engineering	$ 24,722.00
Mining Operation	41,171.00
Monitoring of Water Quality	55,699.00
Post-Mining Operations	21,095.00
General Supervision and Management	43,074.00
Final Report	22,442.00
TOTAL	$209,543.00

Note: Administrative costs for the Department for Natural Resources and Environmental Protection are to be added to this total.

SECTION VII

PREPARATION OF IMPLEMENTATION AND OPERATION PLANS

Implementation of the demonstration project will be carried out in accordance with the mining plans presented in the section on Preliminary Engineering. Before mining operations begin, however, there will be a period of pre-mining activities to prepare for observation of the mining operations and monitoring of the pollution produced by the operations. The pre-mining period will run from April 15, 1976, through September 1976. A 2-month mining period is then anticipated to follow in February and March 1977. A post-mining period will start immediately upon completion of the mining operations and run from April 1977 through June 1978.

Pre-mining activities will include the preparation of detailed design and engineering specifications for the proposed monitoring station. Construction of the monitoring station will then follow, to be completed by December 1975.

A detailed mining plan will be developed upon completion of development of the monitoring plans. After completion, the mining plans will be reviewed in the field and revised as necessary. The pre-mining phase will end with stake-out of the mining plans to guide implementation of the mining operation.

Mining is scheduled to proceed according to the general plan presented in the section on Preliminary Engineering and the detailed plan developed and staked out during the pre-mining phase. All mining activities will be under the direct control of Certicoals Incorporated who, as mine operator, will actually perform the mining work. The Consultant to the Department of Reclamation for this project will regularly inspect mining operations to insure that the mine operator is following the detailed mining plan.

The post-mining activities will begin at the completion of mining operations. An "As Mined" plan will be prepared by the Consultant showing revisions that were made in the original mining plan to account for circumstances that were unforeseen when the original plan was prepared. Only minor revisions are anticipated since the plan will be thoroughly reviewed in the field before mining is under way. The monitoring station will then be removed after it has been in operation for one year after the completion of mining and will become the property of the Environmental Protection Agency. A final report will be prepared by the Consultant after all monitoring and testing of mine discharge has been completed.

The proposed operation schedule is shown on the following page in figure 15.

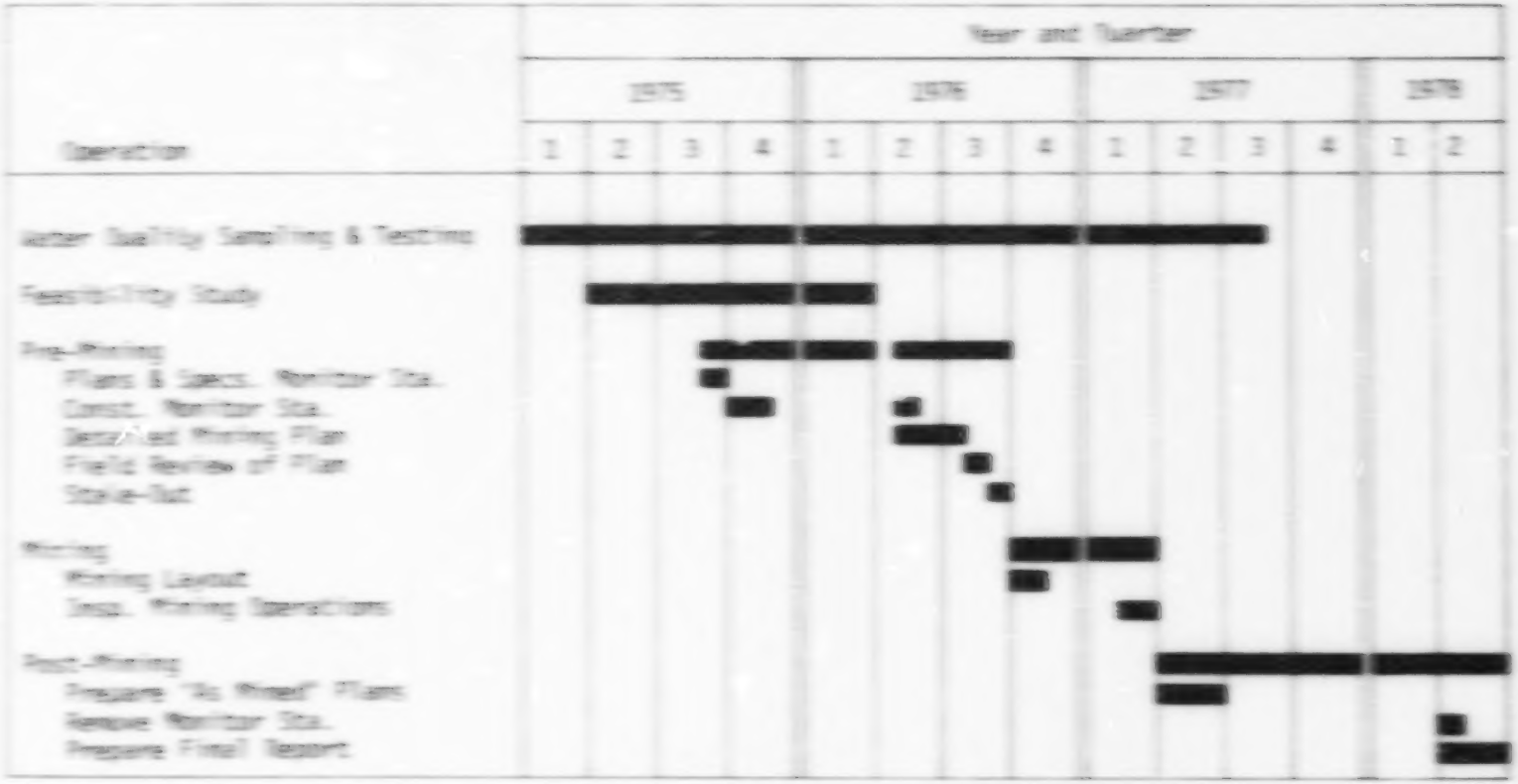


Figure 15. Operation schedule.

The project operation and maintenance budget for the demonstration and post-demonstration periods is presented on page 60. It is estimated that the demonstration will cost $209,543 not including the cost of mining which is to be borne by Certicoals, Inc. The source of funding for this demonstration project is a grant from the U.S. Environmental Protection Agency.

Personnel will be assigned to the project by each organization involved in accordance with the need for personnel. The mining operator will assign his current employees to the mining operations as soon as mining is underway. The Department for Natural Resources personnel will be those normally working in the office or the field to supervise mining activities and no new personnel will be required. The consultant will assign personnel to his work from employees currently on his payroll and no new employees will be required by the consultant either. Since most of the personnel needed by the project are already retained by the organization, personnel will not be a problem.

Supervision of the overall project will routinely be conducted by the Department for Natural Resources using personnel currently supervising mining activities. They have a well established, full-staffed organization of trained and experienced supervisors and inspectors to undertake the Department's responsibilities in the project. They will follow the project through to completion of the final report. The consultant's personnel are likewise fully trained and experienced to take on field supervision and inspection of the demonstration. (For a further discussion of project responsibility and personnel see Capital and Operating Costs under Preliminary Engineering.)

The consultant will be responsible for the preparation of project interim reports and for the final project evaluation reports. Trip reports will not be normally required by the project and will be made only if special trips to the project site are required for significant reasons. Likewise conference reports will be made only if an important meeting occurs during the life of the project. Monthly, quarterly, and annual progress reports will be prepared by the consultant throughout the life of the demonstration project following the format set forth by the Environmental Protection Agency.

SECTION VIII

EFFECTIVENESS OF PROJECT

This project will provide the documentation which has been lacking regarding the modified block-cut method of mining. This method of mining is termed "controlled placement" or "haul back" in other states and has proven to be quite successful. However, full data on disturbed area, sediment yield, revegetation, costs and other pertinent information have not previously been assembled.

DEMONSTRATION VALUE

This project will demonstrate the effectiveness of this mining method in providing onsite control of sedimentation. Preliminary calculations indicate the sediment yield to be very near the existing Commonwealth of Kentucky water quality criteria. With some modifications, the requirement of a sedimentation pond may be eliminated. All of the pollution may be abated at the project site and therefore would not contribute to the pollution of the streams within the State.

The cost of actual pollution control cannot be evaluated in this demonstration as the control is onsite and is an integral part of the mining operation. Overall operating costs have been developed for comparison with other methods, but basic assumptions in these comparisons have been made. The net savings on this project relative to pollution control may be the future elimination of the silt basins depending upon the results of this demonstration and the future State and Federal requirements.

One observation is that the construction of silt basins and the access roads necessary for construction of these facilities may result in the creation of more sediment than the actual mining operation. The sediment yield associated with the demonstration mining method will be well documented. A study of the problems associated with silt basin construction may prove this observation to be correct.

The widespread use of the block-cut method of mining may prove to be an environmentally acceptable solution to the sediment problem. This would improve the quality of the waters of the Commonwealth by providing onsite control of the problem as well as potentially eliminating the requirement for silt basins along with associated problems.

PUBLIC BENEFITS

Public benefits from the demonstration project will be substantial even though they primarily will be confined to improved water quality at the site

and in the receiving streams.

In the introduction to this report there was presented a general discussion of the advantages and disadvantages of the block-cut method of mining as compared to more conventional methods. In this comparison it was concluded that the advantages obviously were superior to the disadvantages, the block-cut method of mining does produce substantially less pollutants, and disturbed land is restored more effectively than with conventional methods. Reclamation, in the form of regrading and revegetation, is accomplished in less time and at less cost, which is a secondary public benefit.

The primary public benefit, improved water quality of the mine runoff, results from the fact that the disturbed area in the block-cut method is about 40 percent of the disturbed area in formerly accepted conventional strip mining methods and that revegetation begins much earlier. These characteristics of block-cut mining are envisioned to result in significant decreases in water pollution from the mined area. Reduction in pollution at the site and in the receiving waters enables the waters to remain in their natural state of quality which thereby enhances recreation opportunities, industrial and agricultural activity, and aesthetic qualities in the area adjacent to and downstream from the project site. By decreasing pollution the fish and wildlife habitat will be improved, water quality standards will be complied with, and water sales and costs will not be affected.

SECTION IX

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SECTION X

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Figure 1-A. Legend for core borings.

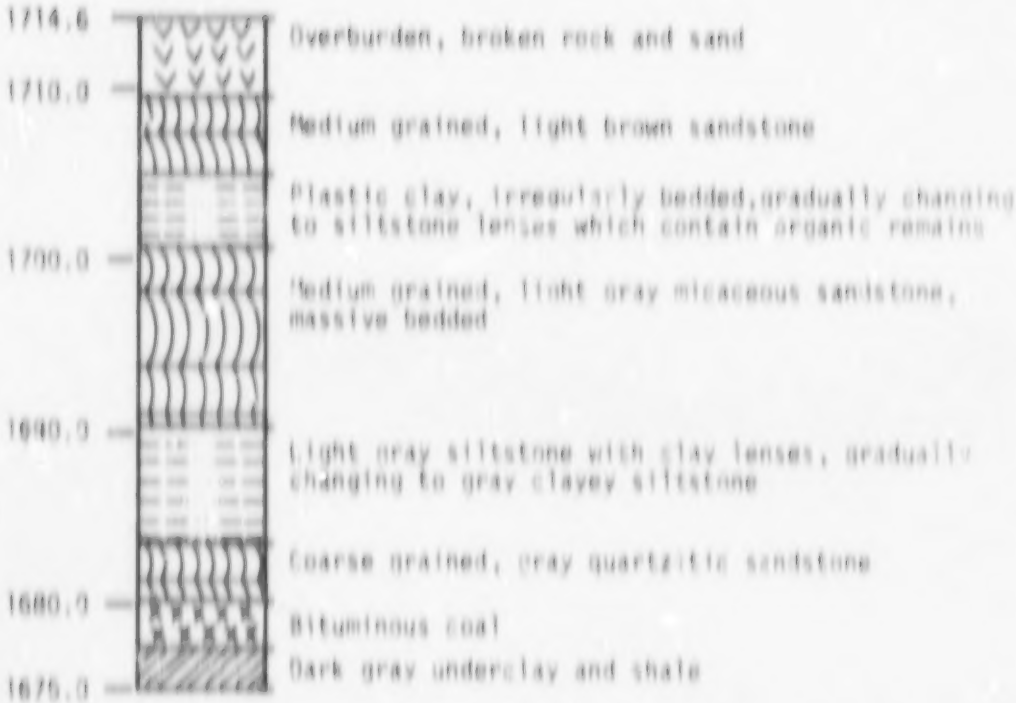
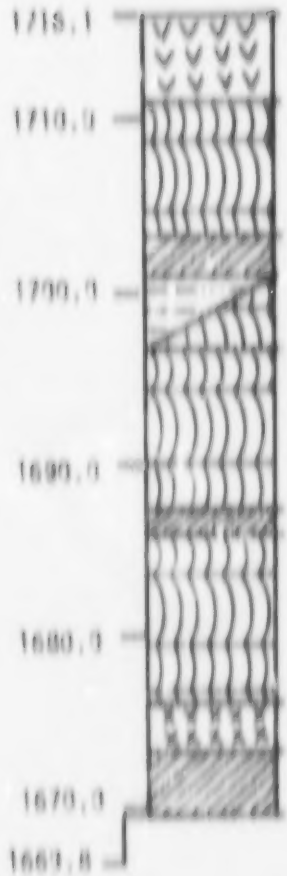

1714.6
1710.0
1700.0
1690.0
1680.0
1675.0
Overburden, broken rock and sand
Medium grained, light brown sandstone
Plastic clay, irregularly bedded, gradually changing to siltstone lenses which contain organic remains
Medium grained, light gray micaceous sandstone, massive bedded
Light gray siltstone with clay lenses, gradually changing to gray clayey siltstone
Coarse grained, gray quartzitic sandstone
Bituminous coal
Dark gray underclay and shale

Figure 2-A, Log of core boring,
Core C-1 located 57' Left of Station 0+75, Baseline "C".



Overburden, soil and rock fragments

Medium grained, light brown, micaceous sandstone gradually changing to medium grained, light gray sandstone with clay lenses

Massive bedded clay

Light gray, silty clay gradually changing to siltstone and then to fine sandstone

Medium grained, light gray sandstone, firmly cemented, changing to coarse sandstone

Light gray clay, medium bedded

Medium grained, light gray sandstone with clay lenses and streaks of coal

Bituminous coal

Underclay gradually changing to gray siltstone, irregularly bedded

Figure 3-A. Log of core boring,
Core C-2 Located 53' Left of Station 2+00, Baseline "C".

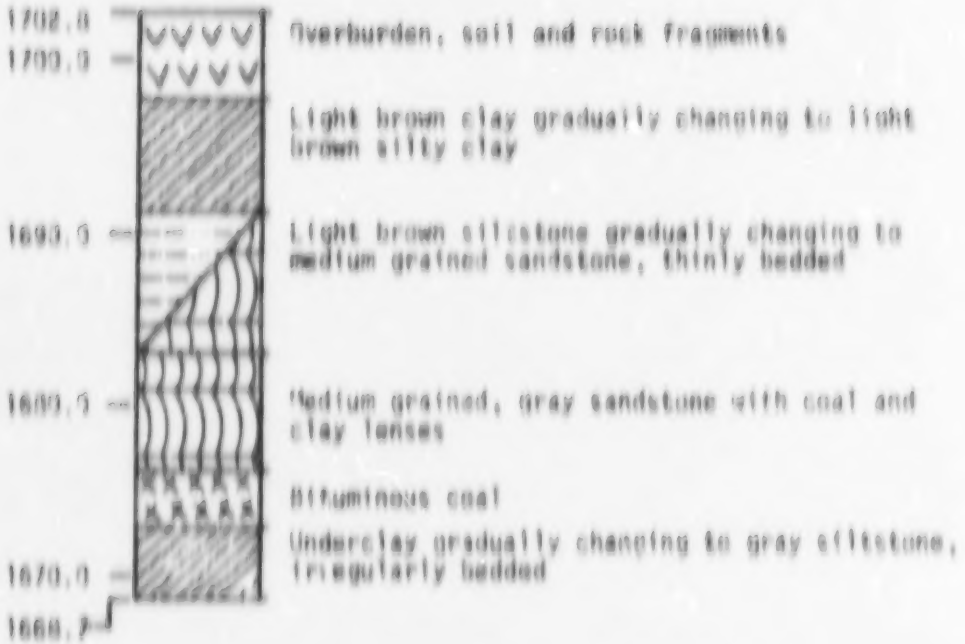

1702.8
1700.0
1693.0
1683.0
1670.0
1668.2
Overburden, soil and rock fragments
Light brown clay gradually changing to light brown silty clay
Light brown siltstone gradually changing to medium grained sandstone, thinly bedded
Medium grained, gray sandstone with coal and clay lenses
Bituminous coal
Underclay gradually changing to gray siltstone, irregularly bedded

Figure 4-A, Log of core boring,
Core C-3 Located 40' Left of Station 4+87, Baseline "C".

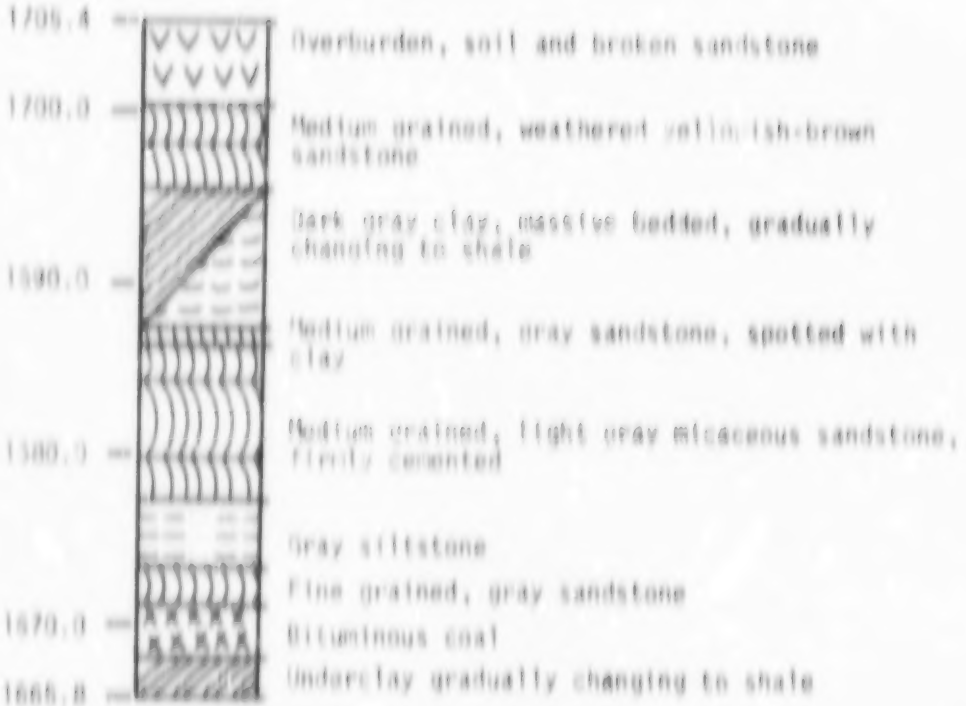


Figure 9-A, Log of core boring,
Core C-4 Located 54' Left of Station 6+75, Baseline "C".

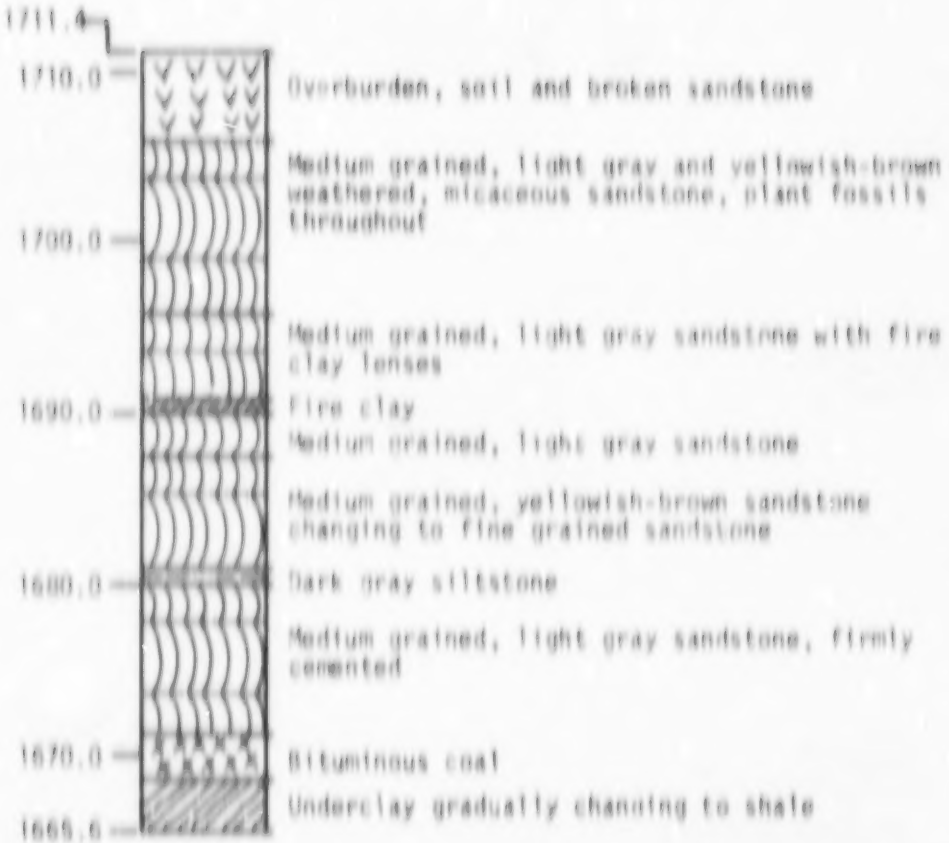


Figure 6-A, Log of core boring,
Core C-5 Located 56' left of Station 8+89, Baseline "C".

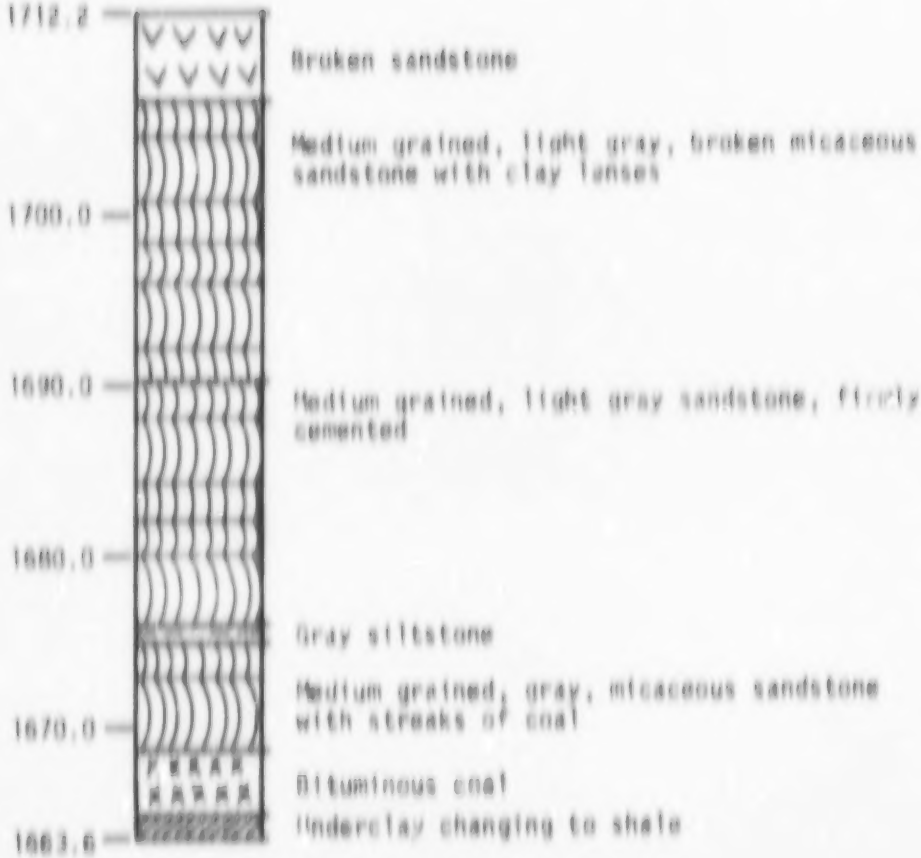


Figure 7-A, Log of core boring, Core C-6 located 210' Ahead of Station 9+87.53, Baseline "C".

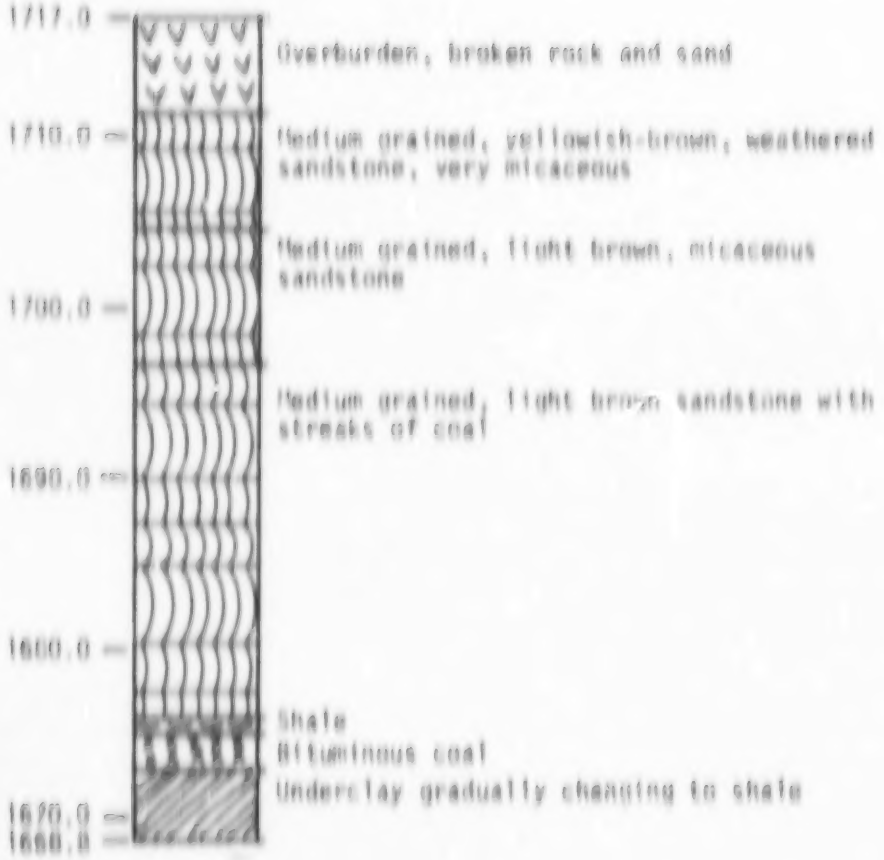


Figure B-A. Log of core boring.
Core C-7 Located 82' Left of Station 10+60, Baseline "C".

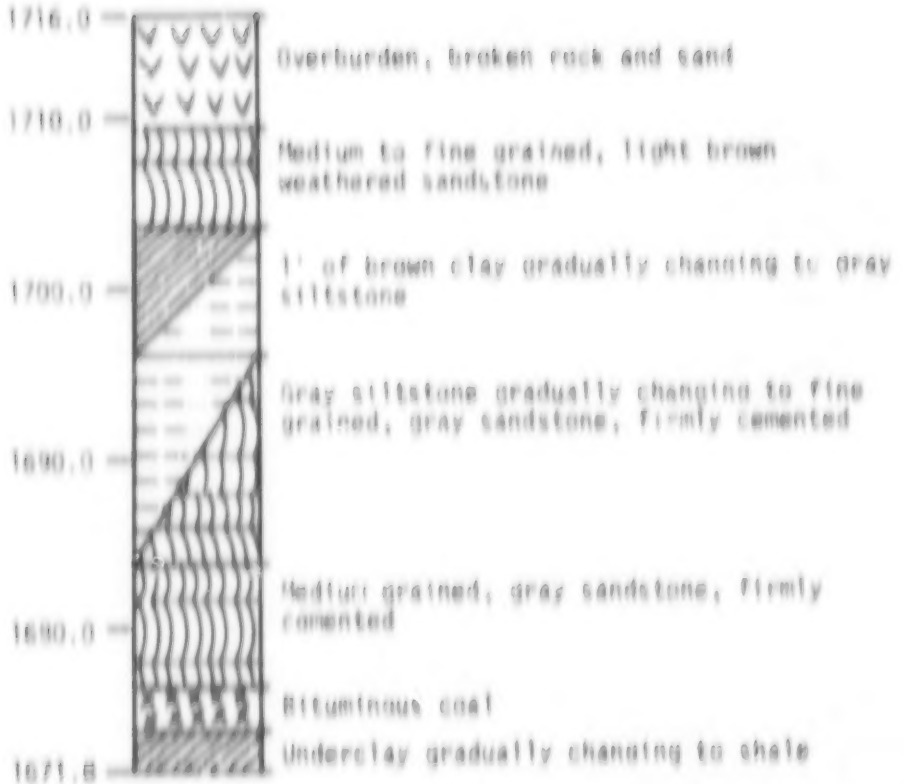

1716.0
1710.0
1700.0
1690.0
1680.0
1671.8
Overburden, broken rock and sand
Medium to fine grained, light brown weathered sandstone
1' of brown clay gradually changing to gray siltstone
Gray siltstone gradually changing to fine grained, gray sandstone, firmly cemented
Medium grained, gray sandstone, firmly cemented
Bituminous coal
Underclay gradually changing to shale

Figure 9-A, Log of core boring.
Core C-8 Located 76' Left of Station 12+42, Baseline "C".

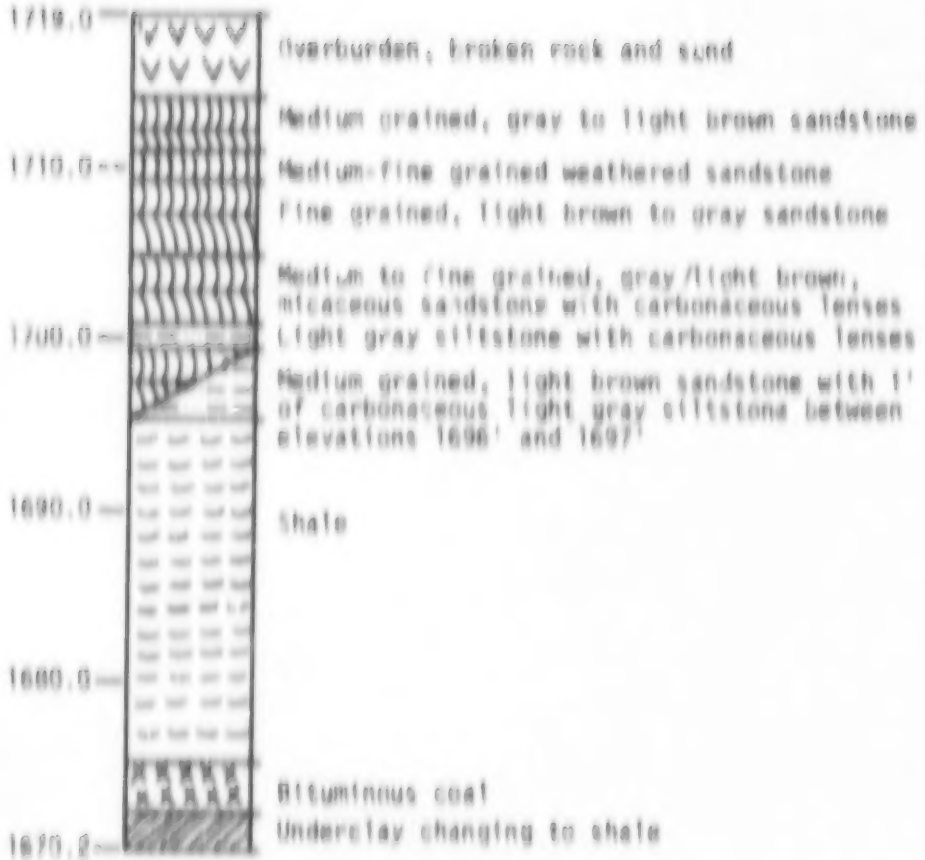

1719.0
1710.0
1700.0
1690.0
1680.0
1670.2
Overburden, broken rock and sand
Medium grained, gray to light brown sandstone
Medium-fine grained weathered sandstone
Fine grained, light brown to gray sandstone
Medium to fine grained, gray/light brown, micaceous sandstone with carbonaceous lenses
Light gray siltstone with carbonaceous lenses
Medium grained, light brown sandstone with 1' of carbonaceous light gray siltstone between elevations 1696' and 1697'
Shale
Bituminous coal
Underclay changing to shale

Figure 10-A, Log of core boring.
Core C-9 Located 83' Left of Station 14+45, Baseline "C".

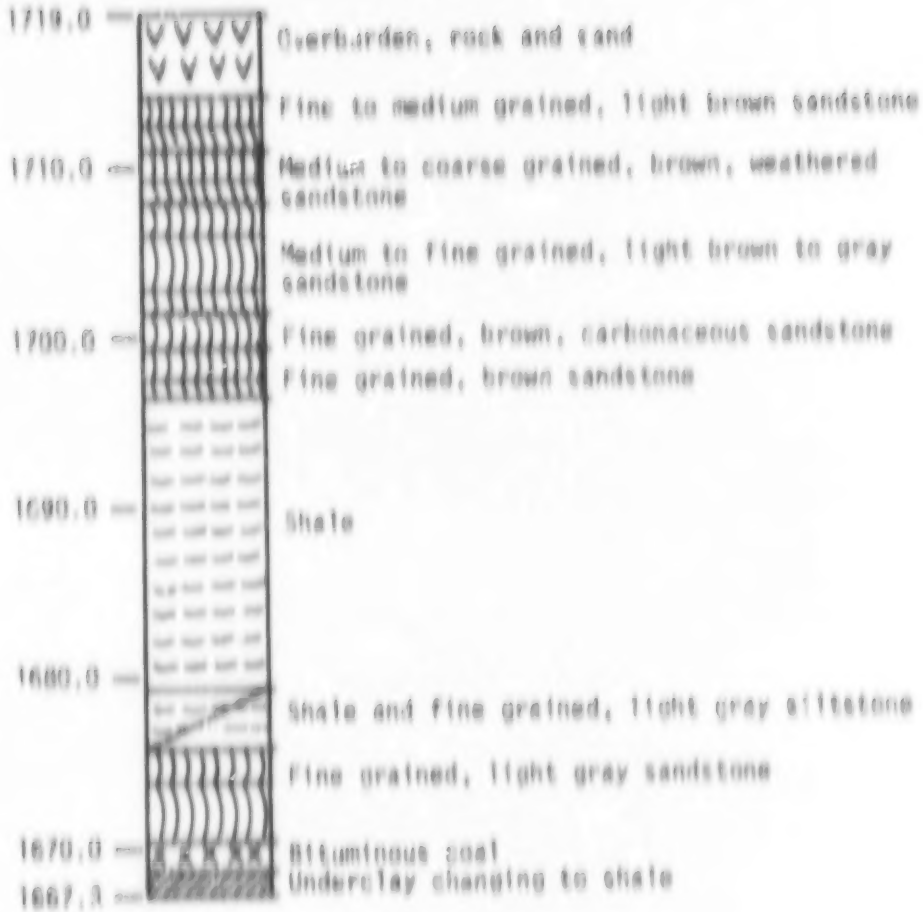


Figure 11-A, Log of core boring.
Core C-10 located 65' Left of Station 16+70, Baseline "C".

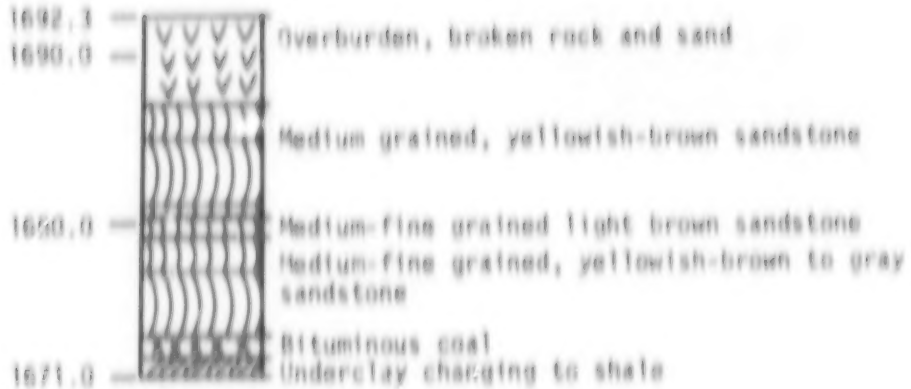


Figure 12-A, Log of core boring,
Core C-11 Located 50' Left of Station 19+20, Baseline "C".

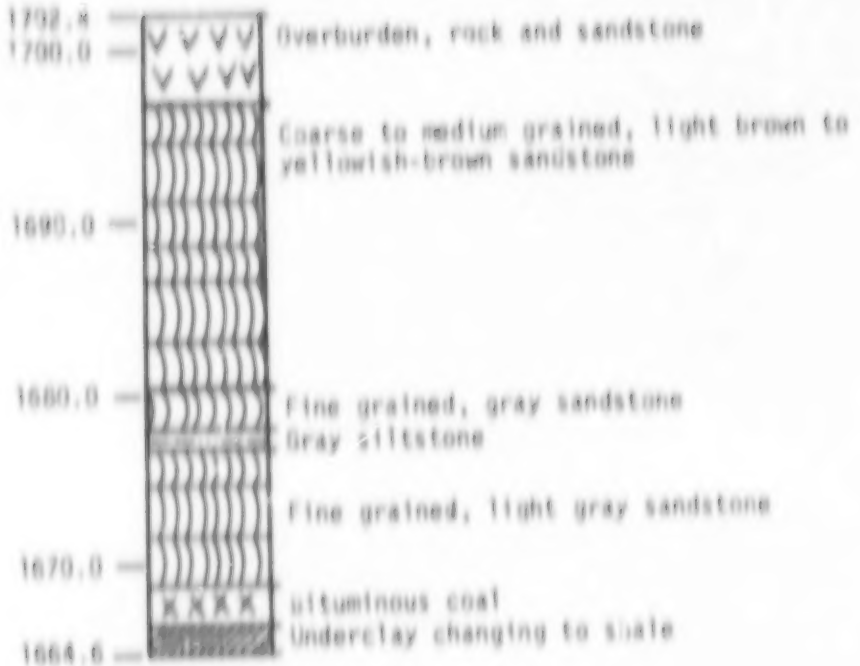


Figure 13-A. Log of boring, Core C-12 located 190' Left of Station 20+90, Baseline "C".

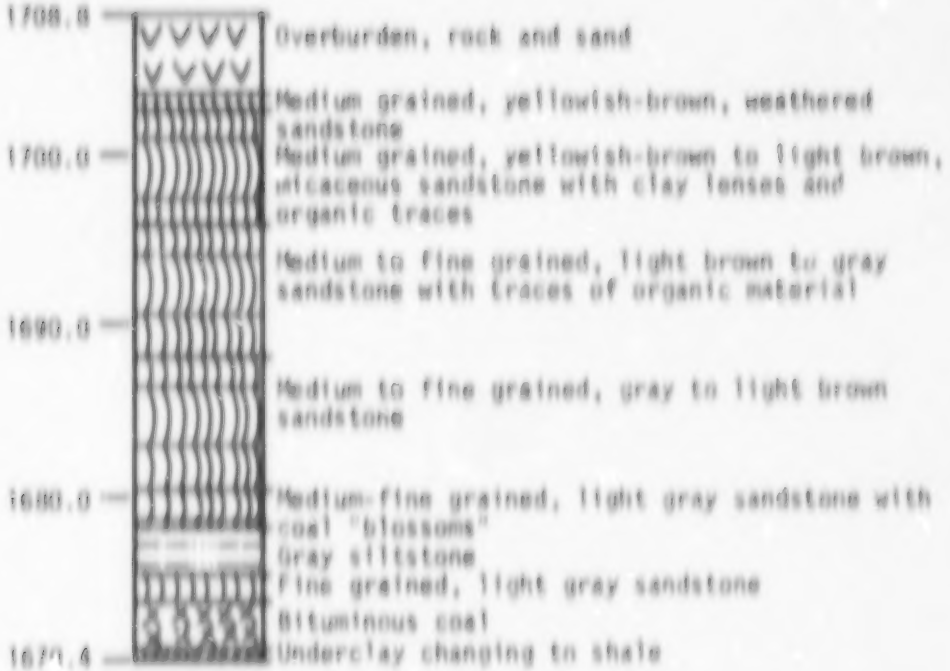

1708.0
1700.0
1690.0
1680.0
1671.4
Overburden, rock and sand
Medium grained, yellowish-brown, weathered sandstone
Medium grained, yellowish-brown to light brown, micaceous sandstone with clay lenses and organic traces
Medium to fine grained, light brown to gray sandstone with traces of organic material
Medium to fine grained, gray to light brown sandstone
Medium-fine grained, light gray sandstone with coal "blossoms"
Gray siltstone
Fine grained, light gray sandstone
Bituminous coal
Underclay changing to shale

Figure 14-A. Log of core boring.
Core C-13 located 120' left of Station 21+85, Baseline "C".

APPENDIX A

TABLE 18. RESULTS OF WATER QUALITY TESTS.

	Date and Sample Numbers								
	1974				1975				
	1	2	3	4	5	6	7	8	9
Parameter	6-12	13-12	20-12	26-12	10-1	16-1	24-1	31-1	7-2
pH units	6.93	6.67	6.75	6.35	6.8	6.67	6.65	6.55	6.43
Conductance, specific, uS	31	32	33.3	34.9	49	39	30	27.9	31.9
Turbidity, NTU (Hach 2100A)	4.6	4.4	3.1	4.3	4.5	3.4	4.0	6.0	7.0
Hardness, total, mg/l as $CaCO_3$	8.3	8.7	9.1	10.1	9.19	8.48	7.43	8.22	8.3
Alkalinity, mg/l as $CaCO_3$	6.3	5.8	6.3	6.8	5.3	4.2	3.88	5.8	7.35
Acidity, mg/l as $CaCO_3$	5.3	4.5	6.3	5.4	5.0	5.0	4.95	6.3	5.85
Iron, total, mg/l	0.09	0.23	0.28	0.28	0.23	0.39	0.20	0.35	0.30
Calcium, mg/l	1.18	0.98	1.30	1.80	1.35	1.05	0.88	1.05	1.04
Magnesium, mg/l	1.26	1.41	1.29	1.23	1.30	1.25	1.18	1.20	1.23
Manganese, mg/l	<0.01	0.03	<0.01	<0.01	0.03	<0.01	0.01	0.02	0.01
Suspended solids, mg/l	30.0	27.5	4.0	4.5	1.2	2.3	2.2	5.6	4.8
Settleable solids, mg/l	2.5	11.0	<0.1	<0.1	0.1	<0.1	<0.1	2.6	2.4
Sulfate, mg/l	<5.0	23.0	21.0	21.0	10.2	10.5	11.3	9.5	9.5

APPENDIX B. CONTINUED

Date and Sample Numbers

1975

	10	11	12	13	14	15	16	17	18
Parameter	12-2	20-2	26-2	5-3	11-3	21-3	27-3	4-4	10-4
pH units	6.49	6.5	6.6	6.7	6.6	6.7	6.7	6.6	6.9
Conductance, specific, uS	30.0	32.0	30.5	36.0	35.5	33.0	32.5	32.5	103
Turbidity, NTU (Hach 2100A)	15.0	4.7	7.1	4.0	14.0	9.0	9.5	7.7	18.0
Hardness, total, mg/l as $CaCO_3$	8.4	8.7	7.9	7.9	8.3	8.4	8.7	8.9	44.7
Alkalinity, mg/l as $CaCO_3$	2.63	3.15	3.15	4.2	4.2	4.2	4.7	4.7	7.4
Acidity, mg/l as $CaCO_3$	4.50	4.95	4.50	2.7	3.2	4.1	3.2	6.3	7.2
Iron, total, mg/l	0.40	0.43	0.34	0.24	0.63	0.35	0.43	0.18	0.23
Calcium, mg/l	1.02	1.12	1.00	1.06	0.93	1.20	1.20	1.56	8.50
Magnesium, mg/l	1.25	1.23	1.12	1.17	1.17	1.16	1.19	1.14	5.46
Manganese, mg/l	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.35
Suspended solids, mg/l	22.4	0.4	8.0	0.4	18.8	8.0	7.2	5.2	14.4
Settleable solids, mg/l	18.8	<0.1	7.2	<0.1	10.0	7.2	2.0	1.2	10.8
Sulfate, mg/l	9.0	8.9	9.2	14.0	15.0	14.0	15.0	10	39

APPENDIX B, CONTINUED

Date and Sample Numbers

1975

	19	20	21	22	23	24	25	26	27
Parameter	16-4	24-4	1-5	8-5	15-5	21-5	27-5	5-6	13-6
pH units	6.5	6.5	6.3	6.9	6.6	6.5	6.5	6.4	6.5
Conductance, specific, uS	38.5	36.2	28	33	33	34	33	37	31
Turbidity, NTU (Hach 2100A)	7.3	6.7	14	18	16	16	14	14	84
Hardness, total, mg/l as $CaCO_3$	8.8	8.2	8.1	9.2	10.6	10.6	14.7	12.3	13.4
Alkalinity, mg/l as $CaCO_3$	6.8	5.8	6.8	5.6	6.3	4.2	6.3	8.4	8.7
Acidity, mg/l as $CaCO_3$	5.0	4.5	7.6	6.7	3.6	6.8	8.8	5.3	6.0
Iron, total, mg/l	0.42	0.40	0.50	0.86	0.95	0.57	1.66	1.04	3.78
Calcium, mg/l	1.40	1.20	1.00	1.10	1.30	1.35	2.00	1.65	1.90
Magnesium, mg/l	1.09	1.08	1.12	1.17	1.23	1.25	1.53	1.30	1.37
Manganese, mg/l	0.04	0.03	0.04	0.06	0.11	0.02	0.23	0.14	0.17
Suspended solids, mg/l	2.4	8.4	8.4	4.0	2.4	18.0	10.0	4.4	43.6
Settleable solids, mg/l	1.2	2.0	2.5	3.6	2.2	10.8	2.8	0.4	1.2
Sulfate, mg/l	10	10	4.0	6.0	2.5	3.1	2.4	4.4	41.0

APPENDIX B, CONTINUED

Date and Sample Numbers

1975

Parameter	28 19-6	29 26-6	30 3-7	31 11-7	32 18-7	33 25-7	34 1-8	35 6-8	36 15-8
pH units	6.4	6.5	6.4	6.2	5.7	6.5	7.0	6.7	6.5
Conductance, specific, uS	43	32	51	395	350	470	620	640	590
Turbidity, NTU (Hach 2100A)	11	8.7	14	9.4	8.7	8.5	23	12	27
Hardness, total, mg/l as $CaCO_3$	14.1	15.5	19.3	180.3	175.1	16.9	19.8	24.3	21.1
Alkalinity, mg/l as $CaCO_3$	8.1	23.6	26.2	14.5	7.6	21.6	22.6	28.1	25.3
Acidity, mg/l as $CaCO_3$	4.6	3.5	8.5	2.5	3.7	9.2	9.0	5.9	8.4
Iron, total, mg/l	0.51	0.75	3.05	0.16	0.08	0.89	1.29	0.58	0.81
Calcium, mg/l	1.85	2.40	3.05	28.06	33.0	2.60	3.00	3.13	3.93
Magnesium, mg/l	1.53	1.56	1.63	21.00	23.00	1.80	2.1	9.78	10.14
Manganese, mg/l	0.05	0.22	0.95	1.61	1.03	0.02	0.06	0.53	0.52
Suspended solids, mg/l	2.4	2.4	18.4	22.8	10.4	8.0	5.2	14	15.2
Settleable solids, mg/l	2.0	1.2	12.4	14.4	5.2	7.6	1.2	8.8	10.8
Sulfate, mg/l	44.4	4.5	6.2	145.0	186.0	7.5	6.1	13.6	16.5

APPENDIX B. CONTINUED

Date and Sample Numbers

1979

Parameter	37 22-8	38 29-8	39 5-9	40 9-9	41 18-9	42 24-9	43 3-10	44 10-10	45 16-10
pH units	6.9	6.5	7.7	6.5	6.6	6.5	6.7	7.3	6.5
Conductance, specific, uS	560	490	4500	3900	470	420	460	390	490
Turbidity, NTU (Hach 2100A)	7.2	24	6.6	8.6	3.9	25	5.7	2.9	4.5
Hardness, total, mg/l as $CaCO_3$	16.7	24.5	194.5	176.0	19.6	23.6	19.6	18.8	15.0
Alkalinity, mg/l as $CaCO_3$	20.9	30.1	11.3	24.6	17.0	13.5	19.5	23.3	21.0
Acidity, mg/l as $CaCO_3$	3.4	15.6	13.5	5.5	2.1	4.5	3.3	5.9	8.3
Iron, total, mg/l	0.30	0.58	1.28	1.22	1.17	1.42	0.29	0.21	0.09
Calcium, mg/l	2.48	3.13	32.32	16.83	4.65	3.05	3.03	3.37	3.05
Magnesium, mg/l	7.25	11.89	2.48	2.73	1.48	1.36	1.65	1.23	1.39
Manganese, mg/l	0.04	0.01	1.82	0.94	0.12	0.25	0.03	0.02	0.03
Suspended solids, mg/l	4.8	20.4	13.2	18.4	5.2	8.0	1.6	2.4	2.8
Settlesble solids, mg/l	3.6	10.0	10.8	9.6	4.0	1.6	0.8	2.0	2.4
Sulfate, mg/l	17.7	10.4	16.4	145.3	1.2	20.2	27.2	2.2	3.5

APPENDIX B, CONTINUED

Data and Sample Numbers

1975

	46	47	48	49	50	51	52	53
Parameter	22-10	29-10	6-11	14-11	20-11	26-11	4-12	11-12
pH units	6.5	6.4	6.5	6.8	6.5	6.5	6.5	6.8
Conductance, specific, uS	440	540	330	34	32.6	33	35	32
Turbidity, NTU (Hach 2100A)	3.8	2.1	3.4	5.5	3.2	2.9	3.5	3.6
Hardness, total, mg/l as $CaCO_3$	20.4	16.4	17.2	12.8	10.4	11.6	12.8	9.8
Alkalinity, mg/l as $CaCO_3$	17.1	14.9	15.0	11.0	10.5	9.3	10.1	11.6
Acidity, mg/l as $CaCO_3$	3.9	4.0	5.9	9.1	7.2	7.5	9.0	3.8
Iron, total, mg/l	0.04	0.03	0.04	0.01	0.02	0.04	0.02	0.13
Calcium, mg/l	3.21	3.37	3.21	3.01	1.76	2.08	3.05	1.84
Magnesium, mg/l	0.96	1.40	1.47	1.87	1.92	1.40	1.45	1.49
Manganese, mg/l	<0.01	0.02	0.02	0.01	0.03	0.02	0.03	<0.01
Suspended solids, mg/l	2.4	1.2	2.4	0.6	4.0	3.6	2.8	1.2
Settleable solids, mg/l	1.6	0.4	1.2	0.1	0.6	3.2	2.0	0.8
Sulfate, mg/l	2.6	3.5	6.9	3.6	3.1	2.8	3.3	8.9

APPENDIX B, CONTINUED

	Date and Sample Numbers						
	1975			1976			
	54	55	56	57	58	59	60
Parameter	16-12	23-12	29-12	6-1	14-1	20-1	28-1
pH units	6.5	6.5	6.4	6.4	6.2	6.8	6.6
Conductance, specific, uS	26	27	28	28	26.0	24.0	29.0
Turbidity, NTU (Hach 2100A)	2.9	2.4	3.3	5.5	3.5	3.7	7.1
Hardness, total, mg/l as $CaCO_3$	11.6	10.6	9.6	9.0	10.2	8.0	9.5
Alkalinity, mg/l as $CaCO_3$	10.2	12.2	11.4	8.0	10.2	8.0	10.0
Acidity, mg/l as $CaCO_3$	8.0	9.2	9.6	8.0	8.2	6.0	8.0
Iron, total, mg/l	0.08	0.11	0.13	0.13	0.09	0.02	0.06
Calcium, mg/l	1.60	1.20	1.52	1.60	1.52	1.40	1.32
Magnesium, mg/l	1.47	1.51	1.49	1.48	1.47	1.19	1.38
Manganese, mg/l	0.01	<0.01	<0.01	0.09	0.07	0.01	0.01
Suspended solids, mg/l	0.4	1.6	3.2	1.0	1.2	1.6	9.6
Settleable solids, mg/l	<0.1	0.0	0.0	0.2	.0	1.2	7.6
Sulfate, mg/l	9.7	10.8	9.4	13.3	9.5	9.2	10.7